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E. GEORGE MAWBEY, M. Inst. C. E.
PAST PRESIDENT.

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Institution of municipal & county engineers, Lond.

PROCEEDINGS

OF THE

INCORPORATED ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS

VOLUME XXVIII. 1901-1902

EDITED BY

THOMAS COLE

ASSOC. M. INST. C.E.

(*Secretary of the Association*)

The Association is not as a body responsible for the facts and opinions advanced herein.

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LIST OF OFFICERS, 1902–1903.

COUNCIL.

President.—THOMAS HENRY YABBICOM, M. Inst. C.E., Bristol.

Vice-Presidents.

J. PATTEN BARBER, M. Inst. C.E., Borough Engineer, Islington.
A. T. DAVIS, Assoc. M. Inst. C.E., County Surveyor, Salop.
W. WEAVER, M. Inst. C.E., Borough Engineer, Kensington.

Ordinary Members of Council.

W. N. BLAIR, M. Inst. C.E., Borough Surveyor, St. Pancras.
J. W. BRADLEY, M. Inst. C.E., City Engineer, Westminster.
J. A. BRODIE, M. Inst. C.E., City Engineer, Liverpool.
E. BUCKHAM, M. Inst. C.E., Borough Surveyor, Ipswich.
A. E. COLLINS, M. Inst. C.E., City Engineer, Norwich.
A. CREER, Assoc. M. Inst. C.E., City Surveyor, York.
A. D. GREATOREX, Assoc. M. Inst. C.E., Borough Surveyor, West Bromwich.
E. P. HOOLEY, Assoc. M. Inst. C.E., County Surveyor, Nottingham.
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A. B. MACDONALD, M. Inst. C.E., City Engineer, Glasgow.
J. PATON, Borough Engineer, Plymouth.
S. S. PLATT, M. Inst. C.E., Borough Surveyor, Rochdale.
J. PRICE, M. Inst. C.E., City Surveyor, Birmingham.
H. T. WAKELAM, M. Inst. C.E., County Surveyor, Middlesex.
C. F. WIKE, M. Inst. C.E., City Surveyor, Sheffield.

Past Presidents.

W. HARPUR, M. Inst. C.E., Borough Engineer, Cardiff.
C. H. LOWE, M. Inst. C.E., 30 Somerset Street, Portman Square, W.
E. G. MAWBEY, M. Inst. C.E., Borough Engineer, Leicester.

Elective Past Presidents.

J. T. EAYRS, M. Inst. C.E., 39 Corporation Street, Birmingham.
J. LOBLEY, M. Inst. C.E., Borough Engineer, Hanley.
O. C. ROBSON, M. Inst. C.E., Surveyor to the Urban District Council, Willesden, N.W.

Honorary District Secretaries.

Eastern District.—J. W. COCKRILL, Assoc. M. Inst. C.E., Great Yarmouth.
Home District.—R. J. THOMAS, M. Inst. C.E., Aylesbury.
Ireland.—R. H. DORMAN, M. Inst. C.E., Armagh.
Lancashire and Cheshire District.—C. BROWNRIDGE, Assoc. M. Inst. C.E., Birkenhead.
Metropolitan District.—J. R. DIXON, Assoc. M. Inst. C.E., Shoreditch.
Midland District.—J. S. PICKERING, Assoc. M. Inst. C.E., Nuneaton.
Northern District.—J. P. DALTON, Ryton-on-Tyne.
Wales (North).—J. W. M. SMITH, Wrexham.
„ (South).—W. E. C. THOMAS, Assoc. M. Inst. C.E., Neath.
Western District.—JOS. HALL, M. Inst. C.E., Cheltenham.
Yorkshire District.—W. H. HOPKINSON, Assoc. M. Inst. C.E., Keighley.

General Hon. Secretary.

C. JONES, M. Inst. C.E.

Honorary Treasurer.

LEWIS ANGELL, M. Inst. C.E.

Secretary.

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PAST PRESIDENTS.

1873–4 1874–5	LEWIS ANGELL, M. Inst. C.E.
1875–6.	*J. G. LYNDE, M. Inst. C.E.
1876–7.	JAMES LEMON, M. Inst. C.E.
1877–8.	*F. ASHMEAD, M. Inst. C.E.
1878–9.	G. F. DEACON, M. Inst. C.E.
1879–80.	*E. PRITCHARD, M. Inst. C.E.
1880–1.	*A. W. MORANT, M. Inst. C.E.
1881–2.	*W. S. TILL, M. Inst. C.E.
1882–3.	C. JONES, M. Inst. C.E.
1883–4.	W. H. WHITE, M. Inst. C.E.
1884–5.	W. G. LAWS, M. Inst. C.E.
1885–6.	*R. VAWSER, M. Inst. C.E.
1886–7.	J. LOBLEY, M. Inst. C.E.
1887–8.	*J. GORDON, M. Inst. C.E.
1888–9.	E. B. ELLICE-CLARK, M. Inst. C.E.
1889–90 1890–91	H. P. BOULNOIS, M. Inst. C.E.
1891–2.	T. DE C. MEADE, M. Inst. C.E.
1892–3.	J. CARTWRIGHT, M. Inst. C.E.
1893–4.	J. T. EAYRS, M. Inst. C.E.
1894–5.	A. M. FOWLER, M. Inst. C.E.
1895–6.	E. R. S. ESCOTT, M. Inst. C.E.
1896–7.	F. J. C. MAY, M. Inst. C.E.
1897–8.	Sir ALEX. R. BINNIE, M. Inst. C.E.
1898–9.	O. C. ROBSON, M. Inst. C.E.
1899–00.	W. HARPUR, M. Inst. C.E.
1900–01.	C. H. LOWE, M. Inst. C.E.
1901–02.	E. GEORGE MAWBEY, M. Inst. C.E.

* Deceased.

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LIST OF MEMBERS.

IT IS PARTICULARLY REQUESTED THAT EVERY CHANGE OF ADDRESS MAY BE COMMUNICATED WITHOUT DELAY TO THE SECRETARY.

* *Those Members against whose names a star is placed have obtained the Certificate of the Association.*

R *signifies re-election under Bye-law* 5*a*. G *elected as Graduate.* A *elected as Associate.* TA *transferred to Associate class.*

HONORARY MEMBERS.

Date of Election and Transfer.		
1897 Oct. 16	BECHMANN, G.	Ingénieur en chef des Ponts et Chaussées, Paris.
1898 Dec. 17	BICKNELL, R. H., M. Inst. C.E.	Local Government Board, Whitehall, S.W.
1888 Mar. 3	CODRINGTON, THOS., M. Inst. C.E.	5 Riverdale Rd., Twickenham Park.
1901 Mar. 23	HASSELT, J. VAN	Director of Public Works, Amsterdam.
1886 June 12	MANSERGH, JAS., M. Inst. C.E.	5 Victoria Street, Westminster, S.W.
1892 Apr. 23	PUTZEYS, E.	Ingénieur en chef, Directeur de la Ville de Bruxelles.
1890 Sept. 13	ROBINSON, HY., M. Inst. C.E.	Parliament Mansions, Westminster, S.W.
1874 June 1	TULLOCH, MAJOR H., R.E.	28 Victoria Street, S.W.

MEMBERS.

1893 Oct. 21	ABRAHAMS, C. V.	City Surveyor, Kingston, Jamaica.
1894 June 21 R1902 Mar. 22	ABURROW, C., M. Inst. C.E...	55 Barnato Buildings, Johannesburg, S.A.
1893 Jan. 14	ADSHEAD, E. E.	Borough Surveyor, Macclesfield.
1896 Jan. 18	AITKEN, T., A.M. Inst. C.E.	County Surveyor, Cupar, Fife.
1897 Jan. 16	ALLEN, A. T...	Surveyor to the Urban District Council, Portslade-by-Sea, Sussex.
1873 May 2	ALLEN, T. T...	Broad Street, Stratford-on-Avon.
1897 June 19	ALVES, G.	Surveyor to the Urban District Council, Glastonbury.
1890 June 26	ANDERSON, R. S., Assoc. M. Inst. C.E.	County Surveyor, Peebles, N.B.
1900 Dec. 15	ANDERSON, W. V...	City Surveyor, Winchester.
G1898 June 30 T1899 Oct. 21	*ANDREWS, S. P.	Surveyor to the Urban District Council, Caversham.
G1894 Oct. 20 T1899 Oct. 21	*ANGEL, R. J.	Borough Surveyor, Bermondsey, S.E.

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Date of Election and Transfer.		
1894 May 19	*ANGELL, J. A., A.M.Inst.C.E.	Surveyor to the Urban District Council, Beckenham, S.E.
1873 Feb. 15	ANGELL, LEWIS, M. Inst. C.E. (*Past President, and Hon. Treasurer.*)	"Calside," Carlisle Road, Eastbourne.
1899 June 29	ANSTEE, J.	Surveyor to the Rural District Council, Guildford.
1880 May 27 R1899 Feb. 25	ARMISTEAD, R., Assoc. M. Inst. C.E.	8 Charles Street, Bradford.
1893 July 31	ARMYTAGE, W. K. L.	Borough Surveyor, Yeovil.
1900 June 16	ASQUITH, A.	Surveyor to the Urban District Council, Holyhead.
1890 June 26	ATKINSON, J., A.M. Inst. C.E.	Borough Surveyor, Stockport.
1897 Feb. 13	BAFF, C. J.	Surveyor to the Urban District Council, Gosforth, Newcastle-on-Tyne.
1900 Feb. 10	BAINS, G.	Surveyor to the Urban District Council, Saltburn-by-the-Sea.
1884 May 29	BAKER, F.	Borough Surveyor, Middlesbrough, Yorks.
1891 Aug. 1	BAKER, J., A.M. Inst. C.E. ..	Surveyor, Slough.
1896 June 25	BALDWIN, L. L., A.M. Inst. C.E.	Surveyor to the Urban District Council, Coalville, Leicester.
G1891 Aug. 1 T1896 Feb. 22	*BALL, B., A.M. Inst. C.E. ..	Borough Surveyor, Nelson, Lancs.
1898 Dec. 17	BALL, F...	Borough Surveyor, Southwold, Suffolk.
G1887 Sept. 17 T1898 Feb. 19	*BALL, G., A.M. Inst. C.E. ..	Surveyor to the Urban District Council, Bexhill.
1879 Oct. 23	BANKS, W., A.M. Inst. C.E.	City Surveyor, Rochester.
1887 Mar. 12	BARBER, J. Patten, M. Inst. C.E. (*Vice-President.*)	Borough Engineer, Islington, N.
G1888 Sept. 15 T1892 July 11	*BARNES, S. W. J., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Hanwell.
1890 May 3	BARRAS, C. C.	Surveyor to the Rural District Council, Doncaster.
1890 Feb. 1	BARRATT, F. W.	Borough Surveyor, Bethnal Green, N.E.
1897 Jan. 16	BARRETT, E. J., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Staines.
1899 Jan. 21	BARRS, J. D.	Surveyor to the Urban District Council, Bromyard.
1898 Jan. 15	BARTON, J. I...	Surveyor to the Urban District Council, St. Helens, Isle of Wight.
1896 Oct. 24	BAYLIS, T. P., A. M. Inst. C.E.	Borough Surveyor, Droitwich.
1891 Sept. 12	BEATSON, W.	Borough Surveyor, Leith.
1894 Jan. 13	BEAUMONT, A.	County Surveyor, Yorks. East Riding. County Hall, Beverley.
1897 Mar. 13	BEAUMONT, G. E.	Surveyor to the Rural District Council, Wortley. "Holme Lea," Greenoside, near Sheffield.

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Date of Election and Transfer.		
1897 Mar. 13	BEAUMONT, T. C.	Surveyor to the Rural District Council, Driffield.
1896 Nov. 28	BELL, A. W., A. M. Inst. C.E.	City Engineer, Dunfermline.
1892 Jan. 16	BELL, G., Assoc. M. Inst. C.E.	Borough Surveyor, Swansea.
1897 Jan. 16	BELL, G. J., Assoc. M. Inst. C.E.	County Surveyor, Cumberland.
1895 Jan. 19	BELLINGHAM, A. W. H., Assoc. M. Inst. C.E.	Municipal Engineer, Tientsin, China.
1896 Jan. 18	BENNETT, H. M.	Surveyor to the Rural District Council, Keynsham, Bristol.
1886 Dec. 18 / R1902 Nov. 8	BENNETT, W. B. G., Assoc. M. Inst. C.E.	Midland Bank Chambers, Southampton.
G1898 Dec. 17 / T1900 July 19	*BENNETTS, J. P.	Surveyor to the Urban District Council, Harrow.
1886 Oct. 16 / R1896 Jan. 18	BERRINGTON, R. E. W., Assoc. M. Inst. C.E.	Graisley, Wolverhampton.
1892 Mar. 11 / R1899 May 6	BESWICK, W. H., Assoc. M. Inst. C.E.	Moss Side, Exmouth.
1891 June 6	BETTANY, F.	Borough Engineer, Burslem.
1902 Mar. 22	BIBBEY, T.	Surveyor to the Urban District Council, Audley, Staffs.
1896 Nov. 28	BIKER, T.	Surveyor to the Urban District Council, Whitworth. Facit, near Rochdale.
1890 Mar. 29	BINNIE, SIR A. R., M. Inst. C.E. (*Past President.*)	9 Gt. George Street, Westminster, S.W.
1896 Nov. 28	BIRD, W. F.	Surveyor to the Urban District Council, Midsomer Norton.
1897 Jan. 16	BIRKS, E.	Highway Surveyor to Rural District Council, Uxbridge.
1891 June 25	BISHOP, McW.	Surveyor to the Urban District Council, Sutton-in-Ashfield, Notts.
1901 Feb. 16	BLACKBURN, J.	Surveyor to the Urban District Council, Soothill Upper.
1873 Feb. 15	BLACKSHAW, W., Assoc. M. Inst. C.E.	Borough Surveyor, Stafford.
1886 June 12	BLAIR, W. N., M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, St. Pancras.
1900 Mar. 10	BLOOD, A. T.	Surveyor to the Urban District Council, St. Neots, Hunts.
1895 Oct. 19	BODEN, E. G.	Surveyor to the Rural District Council, Romford.
1902 Nov. 8	BORG, E. A.	Borough Surveyor, Margate.
1895 Jan. 19	BOTTERILL, C., A.M.Inst.C.E.	583 Fulham Road, Walham Green, S.W.
1878 May 1	BOULNOIS, H. P., M. Inst. C.E. (*Past President.*)	44 Campden House Court, Kensington, W.
1898 Mar. 19	BOWEN, H. W.	District Surveyor, Hayward's Heath.
1898 Feb. 19	BOWLES, A. R., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Sandgate.
1898 Oct. 15	BOYLE, J. C.	City Surveyor, Armagh.
1894 Oct. 20	BRADFORD, J. H.	Surveyor to the Urban District Council, Aylesbury.
G1889 May 18 / T1893 Apr. 22	*BRADLEY, J. W., Assoc. M. Inst. C.E. (*Member of Council.*)	City Engineer, Westminster, S.W.
1897 Jan. 16	BRADLEY, W. L.	Surveyor to the Urban District Council, Tonbridge.

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Date of Election and Transfer.		
G1894 Jan. 13 T1896 Oct. 24	*Bradshaw, F. E. G.	Borough Surveyor, Tamworth.
1873 May 2	Bressey, J. T.	Surveyor to the Urban District Council, Wanstead, Essex.
1891 Mar. 21	Bretland, J. C., M. Inst. C.E.	City Surveyor, Belfast.
1891 Aug. 1	Brett, J. H.	County Surveyor, Co. Antrim. Belfast, Ireland.
1891 Aug. 1	Brettell, W. H.	Surveyor to the Urban District Council, Rowley Regis, Staffordshire.
1894 Oct. 20	Bridges, O. A.	Surveyor to the Urban District Council, Bognor.
1891 Mar. 21	Brierley, J. H., A. M. Inst. C.E.	Borough Surveyor, Richmond, Surrey.
1901 Dec. 7	Brodie, J. A., M. Inst. C.E. (*Member of Council.*)	City Engineer, Liverpool.
1889 Apr. 18	Brodie, J. S., A.M. Inst. C.E.	Borough Engineer, Blackpool.
1894 Oct. 20	Brooke, J.	Surveyor to the Urban District Council, Northwich, Cheshire.
1885 Feb. 7 R1892 Apr. 23	Brooke, W., Assoc. M. Inst. C.E.	Surveyor to the R.D.C., Strood. "Lympstone," Goddington Road, Rochester.
1891 Feb. 21	Broom, G. J. C., M. Inst. C.E.	Borough Engineer, St. Helen's, Lancashire.
1884 July 10	Brown, A., M. Inst. C.E. ..	Borough Engineer, Nottingham.
1898 Jan. 15	Brown, C.	Surveyor to the Urban District Council, Bedlingtonshire.
1881 Jun. 18	Brown, J. W., Assoc. M. Inst. C.E.	Borough Engineer, West Hartlepool.
G1894 July 7 T1898 Sept. 3	*Brown, R., A.M. Inst. C.E.	Surveyor to the Urban District Council, Southall Norwood.
1889 Feb. 9 R1898 Jan. 15	*Brown, R. R.	Electrical Engineer to the Urban District Council, Bridlington.
1893 June 24	Brown, W. I.	Late Borough Surveyor, Northampton.
1893 Mar. 4	*Brownridge, C., A. M. Inst. C.E. (*Member of Council.*)	Borough Engineer, Birkenhead. *Hon. Secretary.* Lancashire and Cheshire District.
1901 Feb. 16	Bryce, J., A.M. Inst. C.E.	Burgh Surveyor, Partick, N.B.
G1899 Feb. 9 T1902 Mar. 22	*Bryning, W. G.	County Surveyor, Northallerton Yorks.
1873 May 2	Buckham, E., M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Ipswich.
1897 July 8 R1902 Mar. 22	Buckley, M. J., Assoc. M. Inst. C.E.	26 Bessborough Terrace, N.C.R., Dublin.
1897 Feb. 13	Bull, H. F., A.M. Inst. C.E.	County Surveyor, Cheshire.
1895 Feb. 16	Bunting, T. F.	Borough Surveyor, Maidstone.
1895 Jan. 19	Burden, A. M., Assoc. M. Inst. C.E.	County Surveyor, Kilkenny.
1892 Sept. 24	Burgess, S. E., M. Inst. C.E.	Borough Engineer, South Shields.
1900 Apr. 21	Burkitt, J. P.	County Surveyor, Fermanagh.
1890 June 7	Bursiam, R.	Borough Surveyor, Congleton.
G1895 Jan. 19 T1902 Jan. 25	*Burton, A., A.M. Inst. C.E.	Borough Engineer, Stoke on-Trent.

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Date of Election and Transfer.		
1897 Jan. 16	BUSBRIDGE, T. A.	Surveyor to the Rural District Council, Spilsby.
1890 Sept. 13	BUTLER, W.	Surveyor to the Urban District Council, Fareham.
1899 June 29	BUTTERWORTH, A. S., Assoc. M. Inst. C. E.	Municipal Engineer, Port Elizabeth, S. Africa.
1895 Dec. 18	BUTTON, F. S., M. Inst C.E.	Consulting Borough Surveyor, Burnley. Blaunel Street, Burnley.
1894 Apr. 6	CAINE, T.. Assoc.M.Inst. C.E.	City Engineer, Worcester.
1891 Dec. 12	CAIRNCROSS, T. W., Assoc. M. Inst. C.E.	St. Barnabas Street, Cape Town, S. Africa.
1895 July 27	CALVERT, W.	Surveyor to the Urban District Council, Hebden Bridge.
1894 June 21	CAMERON, D.	City Surveyor, Exeter.
1891 Oct. 17	CAMPBELL, A. H., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, East Ham, E.
1887 Mar. 12	CAMPBELL, K. F., M. Inst. C.E.	Borough Engineer, Huddersfield.
1888 May 12	CAPON, E. R.	Surveyor to the Urban District Council, Epsom.
1890 Oct. 18 R1899 Jan. 21	CARD, H...	North Street, Lewes.
1891 June 25 R1902 Feb. 22	CARLINE, J., A. M. Inst. C.E.	"Merivale," Catford Hill, S.E.
1901 June 27	CARTER, G. E.	Surveyor to the Rural District Council, Winchester.
1897 June 19	CARTER, G. F., Assoc. M. Inst.. C.E.	Surveyor to the Urban District Council, Mexborough.
1838 Dec. 17	CARTWRIGHT, A. S.	Surveyor to the Urban District Council. Wilmslow, Cheshire.
1900 May 19	CARTWRIGHT, F.	Late Municipal Engineer, Howrah, Bengal.
1873 May 2	CARTWRIGHT, J., M. Inst. C.E. (*Past President.*)	Peel Chambers, Market Place, Bury.
1895 Mar. 16	CASS, R. W.	Surveyor to the Urban District Council, Farnham, Surrey.
1895 Mar. 16 R1899 Feb. 25	CATT, A. J.	"Laurel Dene," Kingston-by-Sea, near Brighton.
1896 Mar. 21	CHADWICK, J...	Surveyor to the Urban District Council, Fenny Stratford.
1901 Dec. 7	CHANCELLOR, W. B.	Surveyor to the Urban District Council, Brownhills, Staffs.
1897 Jan. 16	CHAPMAN, C. R. W.	Surveyor to the Urban District Council, Wembley.
1893 Mar. 4 R1899 May 6	CHARLES, T.	Peterborough Road, Harrow.
1884 Dec. 20	CHART, R. M.	Surveyor to the Rural District Council, Croydon. Town Hall, Croydon.
1900 Feb. 10	CHOWINS, W. H.	Surveyor to the Urban District Council, Lynton.
1884 Oct. 9	CLARE, J., A.M. Inst. C.E.. .	Surveyor to the Urban District Council, Sleaford.
1898 Sept. 3	CLARK, E. O'N.	County Surveyor, Leitrim.
1899 Oct. 21	CLARKE, H. A.	Surveyor to the Urban District Council, Briton Ferry.

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Date of Election and Transfer.		
1898 Oct. 15	CLARRY, W. H.	Borough Surveyor, Sutton Coldfield.
1886 Dec. 18	CLARSON, H. J.	Surveyor to the Rural District Council, Tamworth.
1901 May 11	CLAYTON, F. T.	Borough Engineer, Reigate.
1893 July 31	CLOUGH, W.	Surveyor to the Urban District Council, Audenshaw.
1899 Oct. 21	CLUCAS, R. H.	Borough Surveyor, Kendal.
G1894 July 7 T1896 Oct. 24	*COALES, H. F.	Surveyor to the Urban District Council, Sunbury-on-Thames.
G1886 Oct. 16 T1888 July 12	*COALES, H. G., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Market Harborough.
1882 Sept. 30	COCKRILL, J. W., M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Great Yarmouth; *Hon. Secretary*, Eastern District.
1893 June 24	COCKRILL, T., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Biggleswade, Beds.
1892 Sept. 24	COLLEN, W. M.A., M.Inst.C.E.	County Surveyor, Dublin. 9 Hume Street, Dublin.
1897 July 31	COLLINGWOOD, T. A.	Surveyor to the Urban District Council, Itchen, Woolston, Southampton.
1888 May 12	COLLINS, A. E., M. Inst. C.E. (*Member of Council.*)	City Engineer, Norwich.
1900 Oct. 15 R1901 June 27	COLLINS, G. M.	Town Hall, Withington, Manchester.
1896 Jan. 18	COLLINS, R.	Surveyor to the Urban District Council, Enfield, N.
1886 May 1 R1897 Feb. 13	COMBER, P. F., M. Inst. C.E.	Town Surveyor, Bray. 19 Lower Leeson Street, Dublin.
G1897 July 31 T1900 Dec. 15	*COOK, F. C.	Surveyor to the Urban District Council, Hinckley.
1893 Apr. 22	COOK, F. P., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Mansfield Woodhouse.
G1888 July 12 T1890 Mar. 29	*COOK, J., Assoc. M. Inst. C.E.	Borough Engineer, Cape Town, S. Africa.
1894 Mar. 3	COOKE, E.	Surveyor to the Urban District Council, Abersychan, Pontypool.
G1888 July 12 T1890 Mar. 29	*COOPER, C. H., M. Inst. C.E.	Surveyor to the Urban District Council, Wimbledon.
1898 Sept. 3	COOPER, E. C.	Surveyor to the Urban District Council, Shanklin, Isle of Wight.
1894 Oct. 20	COOPER, F. A., M. Inst. C.E.	Director of Public Works, Colombo, Ceylon.
1887 Sept. 17	COOPER, W. W.	Surveyor to the Urban District Council, Slough.
1893 Apr. 22 R1902 Nov. 8	COPLEY, C. T., A.M.Inst.C.E.	252 Barkerhouse Road, Nelson, Lancashire.
1896 Nov. 28	CORBETT, J.	Borough Engineer, Salford.
1896 Jan. 18	CORDON, R. C.	Surveyor to the Rural District Council, Belper. Hazelwood, Derby.
G1896 May 29 T1897 Jun. 19	*CORRIE, H. W.	Surveyor to the Urban District Council, Lower Bebington, Cheshire.

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Date of Election and Transfer.		
1894 Jun. 21	COTTERELL, A. P. I., Assoc. M. Inst. C.E.	28 Baldwin Street, Bristol; and 17 Victoria Street, S.W.
1891 Jun. 25 R1897 July 31	COVERLEY, J. S.	Surveyor, Penmaenmawr.
1891 Oct. 17 R1899 May 6	COWAN, P. C., M. Inst. C.E.	33 Ailesbury Road, Dublin.
1898 May 21	COX, J.	Surveyor to the Urban District Council, Margam, Port Talbot.
1880 Feb. 7	COX, J. H., M. Inst. C.E. ..	City Surveyor, Bradford.
1900 Mar. 10	CRABTREE, W., A.M.Inst. C.E.	Highway Surveyor to the Rural District Council, Doncaster.
1887 Dec. 10	CRABTREE, W. H. B., M. Inst. C.E.	Borough Surveyor, Doncaster.
1881 May 6	CREER, A., Assoc. M. Inst.C.E. (*Member of Council.*)	City Surveyor, York.
1900 July 19	CROSS, A. W.	Surveyor to the Urban District Council, King's Norton.
1889 Dec. 14	*CROWTHER, J. A., Assoc. M. Inst. C.E.	Borough Surveyor, Southampton.
1900 Jun. 16	CUMMING, W.	Highway Surveyor to the Rural District Council, Lanchester, co. Durham.
1889 Dec. 14	CURRALL, A. E.	Surveyor to the Rural District Council, Solihull, Warwickshire.
1896 Apr. 25	CURRY, W. F.	P. W. D., Volksrust, S. Africa.
1893 Mar. 4 R1899 Feb. 25	CURRY, W. T., A. M. Inst.C.E.	"Beverley," Stroud Road, Gloucester.
1897 Feb. 13	CUTLER, H. A., A.M.Inst.C.E.	City Surveyor, Cork.
1893 Jun. 24	*DALTON, J. P. .. .. .. (*Member of Council.*)	Surveyor to the Urban District Council, Ryton-on-Tyne; *Hon. Secretary*, Northern District.
1899 Jan. 21	DAVIDSON, J. F.	Surveyor to the Urban District Council, Willington Quay.
1900 Oct. 15	DAVIES, W. J.	Surveyor to the Urban District Council, Nantyglo and Blaina. Council Offices, Blaina.
1880 Apr. 10	DAVIS, A. T., Assoc. M. Inst. C.E. (*Vice-President.*)	County Surveyor, Salop.
1900 Oct. 15	DAWSON, C. F.	Surveyor to the Urban District Council, Barking.
1884 Apr. 19 R1902 Nov. 8	DAWSON, C. J.	Wykeham House, Barking.
1896 July 25	DAWSON, N. H.	Borough Surveyor, Banbury.
1879 May 1	DAWSON, W., M. Inst. C.E.	Surveyor to the Urban District Council, Leyton, N.E.
1898 Jan. 15	DAY, C.	Borough Surveyor, Chatham.
1873 Dec. 9	DEACON, G. F., M. Inst. C.E. (*Past President.*)	16 Great George Street, Westminster, S.W.
1898 Jan. 15	DEANE, J.	Surveyor to the Urban District Council, Smallthorne.
1892 Mar. 11	*DEARDEN, H., A. M. Inst. C.E.	Borough Engineer, Dewsbury.
1895 Oct. 19	DEBNAM, A. W.	Surveyor to the Urban District Council, East Stonehouse, Devon.

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Date of Election and Transfer.		
1890 Feb. 1	DENNIS, N. F., A.M.Inst.C.E.	Surveyor to the Urban District Council. Aldershot.
1880 May 27	DENT, W.	Railway Street, Nelson, Lancashire.
1890 Sept. 13	DEVERELL, T. C., Assoc. M. Inst. C.E.	City Engineer, Calcutta.
1896 July 25	DEWHIRST, J...	Surveyor to the Rural District Council, Chelmsford.
G1898 Oct. 15 T1899 Jun. 10	*DICKINSON, A. J.	Surveyor to the Rural District Council, Long Crendon, Thame, Oxon.
1895 June 27	DICKINSON, R.	Surveyor to the Urban District Council, Berwick-on-Tweed.
1890 Sept. 13 R1896 Jan. 18	DICKINSON, T. R., Assoc. M. Inst. C.E.	17 Clifton, York.
1900 Feb. 10	DIGGLE, JAMES	Surveyor to the Urban District Council, Matlock.
1881 Dec. 10	DIGGLE, J., A.M. Inst. C.E.	Water Engineer, Heywood.
1889 Sept. 21	DIGGLE, WM.	Surveyor to the Rural District Council, Runcorn. Frodsham, Chester.
1877 Oct. 20	DITCHAM, H.	Borough Surveyor, Harwich.
1897 Apr. 10	DIVER, D. J.	Surveyor to the Urban District Council, Desborough.
1897 Jan. 16	DIXON, F. J., A.M. Inst. C.E.	Prospect Crescent, Harrogate.
G1891 Aug. 1 T1896 Oct. 24	*DIXON, J. R., A.M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Shoreditch. *Hon. Secretary*, Metropolitan District.
1887 June 18	DIXON, R., Assoc.M.Inst.C.E.	Borough Surveyor, Stratford-on-Avon.
1889 July 4	DODD, P., Assoc. M. Inst.C.E.	Borough Surveyor, Western District, Wandsworth, S.W.
1897 Jan. 16	*DODGEON, A.	Surveyor to the Urban District Council, Clayton-le-Moors.
1888 May 12	DORMAN, R. H., M. Inst. C.E. (*Member of Council.*)	County Surveyor, Armagh; *Hon. Secretary*, Irish District.
1898 June 30	DORMER, P. C.	Surveyor to the Urban District Council, Chesham, Bucks.
1899 Oct. 21	DRYLAND, A.	County Surveyor, Hereford.
1891 Dec. 12	DUFFIN, W. E. L., M. Inst. C.E.I.	County Surveyor, Waterford, Ireland.
1900 Dec. 15 R1901 June 8	DUNCH, T. H.	59 Darnley Road, Gravesend.
1898 May 21	DUNN, J...	Surveyor to the Rural District Council, Chesterton. Brunswick House, Cambridge.
1873 Feb. 15	DUNSCOMBE, C., M.A., M. Inst. C.E.	92 Victoria Street, Westminster, S.W.
G1891 Jan. 21 T1892 Sept. 24	*DYACK, W., M. Inst. C.E.	Burgh Surveyor, Aberdeen.
1882 June 29	DYER, S...	Surveyor, Bridlington.
1879 May 1	EARNSHAW, J. T., Assoc. M. Inst. C.E.	Borough Surveyor, Ashton-under-Lyne, Lancashire.
1900 May 19 R1901 Dec. 7	*EASTWOOD, J.	Town Hall, Halifax.
1883 Aug. 4	EATON-SHORE, G., Assoc. M. Inst. C.E.	Borough Surveyor, Crewe.

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Date of Election and Transfer.		
1877 Nov. 18	EAYRS, J. T., M. Inst. C.E. (*Past President.*) (*Member of Council.*)	39 Corporation Street, Birmingham.
1890 May 3	EBBETTS, D. J.	Surveyor to the Urban District Council, Acton.
1893 Mar. 4	ECKERSLEY, W.	Surveyor to the Urban District Council, Chadderton, Lancashire.
1890 Feb. 1	EDDOWES, W. C.	Borough Surveyor, Shrewsbury.
1891 Jan. 21 a1896 Jan. 18	*EDGE, F. J., A. M. Inst. C.E.	City Engineer, Newcastle-on-Tyne.
1888 May 12	EDINGER, P.	Surveyor to the Urban District Council, Frome.
1891 Sept. 12	EDMONDSON, S.	Surveyor to the Rural District Council, Burnley.
1896 Jan. 18	EDSON, W.	City Surveyor, Ripon.
1899 Mar. 25	EDWARDS, J. V.	County Surveyor, West Riding, Yorkshire. Wakefield.
1898 Apr. 23	EDWARDS, T. L.	County Surveyor. Glamorgan. Bridgend, Glam.
1897 July 31	*ELFORD, E. J.	Surveyor to the Urban District Council, Portland.
1885 Oct. 3	ELFORD, J.	Borough Surveyor, Poole.
1873 Feb. 15	ELLICE-CLARK, E. B., M. Inst. C.E. (*Past President.*)	34 Victoria Street, Westminster, S.W.
1900 Apr. 21	ELLIOTT, F. T.	Surveyor to the Rural District Council, Isle of Thanet. Birchington-on-Sea.
1893 Oct. 21 B1901 Feb. 16	ELLIS, R. E., M. Inst. C.E. ..	70–72 Chancery Lane, W.C.
1895 July 27	ENTWISLE, H.	Surveyor to the Urban District Council, Swinton, near Manchester.
1873 May 2	ESCOTT, E. R. S., M. Inst. C.E. (*Past President.*)	16 Clifton Road, Halifax.
1896 June 25	EVANS, A. J. L.	Borough Surveyor, Luton.
1897 Jan. 16	EVANS, E., A. M. Inst. C.E.	County Surveyor, Carnarvonshire.
1895 Jan. 19	EVANS, E. I., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Penarth, South Wales.
1896 May 29	EVANS, J. P.	Surveyor to the Rural District Council, Wrexham.
1890 June 7	FAIRLEY, W., A.M. Inst. C.E.	Richmond Main Sewerage Board, Kew Gardens, S.W., and 69 Victoria Street, S.W.
c1898 June 30 T1899 Feb. 25	*FARNHAM, W. A.	Surveyor to the Urban District Council, Foots Cray.
1887 July 14	FARRALL, T.	Surveyor to Urban District Council, Sherborne, Dorset.
1893 July 31	FARRINGTON, T. B.	Trinity Square, Llandudno.
1896 Jan. 18	FARRINGTON, W., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Woodford Green, Essex.
1896 Nov. 28	FEATHER, F.	Surveyor to the Urban District Council, Chepstow.

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Date of Election and Transfer.		
1896 Jan. 18	FELKIN, H. R.	Surveyor, Southall Norwood.
1900 Dec. 15	FELLOWS, T. E.	Surveyor to the Urban District Council, Willenhall.
1894 Jan. 13	FENN, T...	Surveyor to the Urban District Council, Belper.
1887 Sept. 17 R1899 June 10	FIDDIAN, W.	Engineer to Stourbridge and Stour Valley Sewerage Boards. Old Bank Offices, Stourbridge.
1899 Jan. 21	FIDLER, A.	Borough Engineer, Northampton.
1894 Jan. 13	FINDLAY, R., A.M. Inst. C.E.	Surveyor, Eltham Green, S.E.
G1892 May 28 T1897 Jan. 16	*FITTON, G.	Borough Surveyor, Basingstoke.
1895 Oct. 19	FLEMING, M. J.	Borough Surveyor, Town Hall, Waterford.
1893 Jan. 14 R1899 May 6	FLOWER, T. J. M., Assoc. M. Inst. C.E.	Scottish Buildings, Baldwin Street, Bristol, and 28 Victoria Street, Westminster, S.W.
G1895 July 27 T1899 Jan. 21	*FORBES, A. H.	Surveyor to the Urban District Council, Saffron Walden.
1896 Nov. 28	FORD, G...	City Surveyor, St. Albans.
1888 July 12	FORDER, W. G., A.M.Inst.C.E.	107 High Road, Lee, S.E.
1897 Jan. 16	FORRESTER, R.	Surveyor to the Rural District Council, Basingstoke.
1890 Sept. 13	FOSTER, T.	Surveyor to the Urban District Council, Hoylake and West Kirby.
1900 June 16	FOTHERGILL, J. E.	Surveyor to the Urban District Council, Brentwood.
1873 May 2	FOWLER, ALFRED M., M. Inst. C.E. (*Past President.*)	1 St. Peter's Square, Manchester; and 35 Old Queen Street, Westminster, S.W.
1897 Mar. 13	FOX-ALLIN, C. J.	Surveyor to the Urban District Council, Smethwick.
G1888 May 12 T1893 Oct. 21 R1898 Jan. 15	*FRANKS, T.W., Assoc. M. Inst. C.E.	Sevcirg Chambers, Lewes.
G1898 June 30 T1902 Nov. 8	*FRASER, R. W.	Surveyor to the Urban District Council, Gainsborough.
1895 Oct. 19	FROST, H.	Surveyor to the Urban District Council, Gosport and Alverstoke. Gosport.
1887 June 18 R1898 Jan. 15	FRY, W. H., A.M. Inst. C.E.	9 High Street, Gosport.
1877 Oct. 20	GAMBLE, S. G., Assoc. M. Inst. C.E.	Metropolitan Fire Brigade, Southwark Bridge Road, S.E.
1885 June 6	GAMMAGE J.	Borough Surveyor, Dudley.
1895 June 27	GAMMELL, H. H.	Surveyor to the Urban District Council, Perry Barr, near Birmingham.
1891 Dec. 12 R1899 June 10	GARRATT, C. T.	Estate Office. Newtown Linford, Leicestershire.
1894 Mar. 3	GARRETT, J. H.	County Surveyor, Worcester.

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Date of Election and Transfer.		
1886 Mar. 13 R1902 Feb. 22	GASKELL, P.	Albert Chambers, Carr Lane, Hull.
1886 Dec. 13	GEEN, H.	Borough Surveyor, Okehampton.
1902 Jan. 25	GENT, T. W. B.	Surveyor to the Rural District Council, Leigh.
1901 Oct. 19	GIBBS, A. G.	Surveyor to the Rural District Council, Midhurst, Sussex.
1900 Mar. 10	GIBSON, S.	Surveyor to the Urban District Council, Biddulph.
1889 Dec. 14	GINN, A. F.	District Surveyor to the Kent County Council, Tonbridge. 70 Quarry Hill, Tonbridge.
1899 June 10	GLADWELL, A.	Highway Surveyor, Rural District Council, Eton. 1 Wrexham Road, Slough, Bucks.
1893 May 13	*GLOYNE, R.M., Assoc. M. Inst. C.E.	District Engineer, Spring Gardens, S.W.
1891 May 2	GODFREY, B., A.M. Inst. C.E.	Surveyor to the Rural District Council, Rotherham.
1883 Feb. 17 R1897 Apr. 10	GODFREY, R., Assoc. M. Inst. C.E.	"Kilburn," Easingwold, Yorks.
1895 Jan. 19	GOLDER, T. C.	Borough Surveyor, Deal.
1873 Nov. 8	GOLDSWORTH, W.	Surveyor to the Urban District Council, Prescot, Lancashire.
1899 June 10	GONDIE, A. H.	Borough Engineer, Stirling.
1886 June 12	GOODYEAR, H., Assoc. M.Inst. C.E.	Borough Surveyor, Colchester.
1897 June 19	GORDON, F.	Surveyor to the Rural District Council, Halifax. Clifton, Brighouse.
1901 Dec. 7	GORDON, J. C.	Borough Surveyor, Aldeburgh, Suffolk.
1897 Oct. 16	GRAHAM, G. A.	Surveyor to the Urban District Council, Witney.
e1897 June 19 T1901 Dec. 7	*GRANT, F. T...	Borough Surveyor, Gravesend.
e1887 Feb. 5 T1893 Apr. 22	*GREATOREX, A.D., A. M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, West Bromwich.
1895 Mar. 5	GREEN, A. A.	Borough Surveyor, Brackley.
1899 June 10	GREEN, G.	Borough Engineer, Wolverhampton.
1901 Feb. 16	GREEN, J. S.	Borough Engineer, Haslingden.
1897 Mar. 13	GREEN, W.	Surveyor to the Urban District Council, Castleford.
1890 May 3 R1898 Apr. 23	GREENWELL, A., Assoc. M. Inst. C.E.	9 Victoria Street, Westminster, S.W.
1883 May 5 R1891 Dec. 12	GREENWOOD, A.	39 Calder Street, Todmorden.
1898 Mar. 19	GREGORY, T.	Surveyor to the Urban District Council, Newburn-on-Tyne.
1892 Jan. 16	GREGSON, G.	Surveyor to the Rural District Council, Durham.
1886 Oct. 16	GREGSON, J., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Padiham, near Burnley.
1882 Sept. 30	GRIEVES, R.	Surveyor to the Urban District Council, Cowpen, Blyth, Northumberland.
1897 June 19	GRIEVES, W. H.	Surveyor to the Urban District Council, Buxton.

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Date of Election and Transfer.		
1892 Mar. 11	GRIFFITH, F., M. Inst. C.E.	Corporation Waterworks Engineer, Leicester.
1886 Sept. 11	GRIMLEY, S. S., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Hendon.
1899 Dec. 16	GRIMSHAW, F. H.	Surveyor to the Urban District Council, Atherton.
1898 Dec. 17	GUILBERT, T. J.	States Surveyor, Guernsey.
1892 Apr. 28	GUNNIS, J. W.	County Surveyor, Longford, Ireland.
1890 Mar. 29	GUNYON, C. J., A.M. Inst.C.E.	Surveyor to the Urban District Council, Wood Green, N.
1891 Dec. 12	HACKETT, E. A., M.E., M. Inst. C.E.	County Surveyor, Clonmel, Tipperary, Ireland.
1885 June 6	HAIGH, J., A.M. Inst. C.E. ..	Borough Surveyor, Abergavenny.
1896 Apr. 25	HAINSWORTH, M.	Surveyor to the Urban District Council, Teddington.
1897 June 19	HAGUE, S.	Surveyor to the Urban District Council, Dukinfield.
1902 Sept. 6	HALE, A.	Municipal Engineer, Howrah, Bengal.
G1899 Dec. 16 T1901 Oct. 19	*HALL, C.	Surveyor to the Urban District Council, Droylsden, near Manchester.
1902 Nov. 8	HALL, E.	Borough Surveyor, Carnarvon.
1884 Apr. 19	HALL, J., Assoc M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Cheltenham; *Hon. Secretary*, Western District.
1886 May 1	HALL, W., A.M. Inst. C.E.	Surveyor to the Urban District Council, Great Crosby.
1900 June 16	HALLAM, R.	Surveyor to the Rural District Council, Eton.
1901 May 11	HALLER, J. C.	Surveyor to the Urban District Council, Guiseley.
1894 July 7	HAMAR, A.	Borough Surveyor, Bishop's Castle, Shropshire.
1887 Mar. 12	HAMBY, G. H., A.M. Inst. C.E.	Borough Engineer, Lowestoft.
1897 Feb. 13	HAMP, H. J., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, New Swindon.
1897 Mar. 13	HANSON, J. H.	Surveyor to the Urban District Council, Cottingham, Yorks.
1890 Sept. 13	HANSON, W.	Surveyor to the Rural District Council, Wantage.
1896 Jan. 18	HARA, R.	Engineer to Tokio Fu, Japan.
1873 May 2	HARDING, J. R., M. Inst. C.E.	Surveyor, Epsom, Surrey.
G1896 Nov. 28 T1899 Jun. 10	*HARDING, W. D.	Surveyor to the Urban District Council, Exmouth.
1899 Jun. 29	*HARGREAVES, J. E.	Surveyor to the Urban District Council, Farnborough, Hants.
1896 Oct. 24	HARLOCK, H., A.M. Inst. C.E.	51 Stanley Gardens, Hampstead, N.W.
1899 May 6	HARMAN, E. A., M. Inst. C.E.	Corporation Gas Engineer, Huddersfield.
1897 Mar. 13	HARPUR, A. O.	Surveyor to the Urban District Council, Caerphilly.

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Date of Election and Transfer.		
1894 Mar. 3	HARPUR, W., M. Inst. C.E. (*Past President.*) (*Member of Council.*)	Borough Engineer, Cardiff.
1896 Jan. 18	HARRIS, F.	Surveyor to the Rural District Council, Tonbridge. Bidborough, Tunbridge Wells.
1901 May 11	HARRISON, A.	Borough Engineer, Southwark, S.E.
1899 Jun. 29	HARRISON, G. F. P.	Surveyor to the Rural District Council, East Stow. Stowmarket, Suffolk.
1896 Nov. 28	HARSTON, W., A.M. Inst. C.E.	Surveyor to the Urban District Council, Dartford.
1896 Oct. 24	HARTLEY, T. H.	Borough Surveyor, Colne.
1887 Jun. 18	HARTY, S., M. Inst. C.E. I. ..	City Engineer, Dublin.
1893 Oct. 21	HARVEY, T. F., Assoc. M. Inst. C.E.	Engineer to the Urban District Council, Merthyr Tydvil.
1892 Apr. 23	HAWLEY, G. W.	York Chambers, King Street, Nottingham.
1896 Jan. 18	HAYCROFT, J. I., A. M. Inst. C.E.	Borough Engineer, Woollahra, Sydney.
1902 July 10	HAYNES, H. T.	City Engineer, Hawthorn, Victoria, Australia.
1895 Apr. 20	HAYNES, R. H.	Borough Engineer, Newport, Mon.
c1897 June 19 r1898 Jan. 15	*HAYWARD, T. W. A.	Borough Surveyor, Sudbury, Suffolk.
1899 June 10	HEATH, J.	Surveyor to the Urban District Council, Urmston.
1885 June 6	HEATON, G., Assoc. M. Inst. C.E.	Surveyor to the Urban District Councils, Abram and Pemberton. King Street, Wigan.
1890 Feb. 1	HENDERSON, A. J., Assoc. M. Inst. C.E.	Surveyor to the District Highway Board, Kingston-on-Thames.
c1895 Jun. 27 r1901 Oct. 19	*HENDRY, J. S.	Surveyor to the Urban District Council, Cannock, Staffs.
1897 Feb. 13	HENRY, T.	Surveyor to the Rural District Council, East Retford.
1892 June 11	HEBON, J., B.E., B.A.	County Surveyor, Co. Down. Courthouse, Downpatrick, Ireland.
1902 May 10	HESLOP, R.	Surveyor to the Urban District Council, Tanfield, Co. Durham.
1899 May 6	HESLOP, T. H. B.	County Surveyor, Norfolk C. C. Norwich.
1875 Dec. 21	HEWSON, T., M. Inst. C.E. ..	City Engineer, Leeds.
1894 July 7	HIGGENS, T. W. E., Assoc. M. Inst. C.E.	Borough Surveyor, Town Hall, Chelsea, S.W.
1898 May 21	HIGGINS, J.	Chief Engineer, Grey Co., New Zealand.
1898 Dec. 17	HINCHCLIFFE, D.	Surveyor to the Urban District Council, Northallerton.
1893 July 13	HIND, H.	Surveyor to the Urban District Council, Erith.
1902 July 10	*HINES, C. E.	Surveyor to the Urban District Council, Windermere.
1898 Sept. 3	HIRST, R. P., A.M. Inst. C.E.	Borough Surveyor, Southport.

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Date of Election and Transfer.		
1895 June 27	Hodgson, W.	Surveyor to the Urban District Council, Keswick.
1873 Feb. 15 R1885 Dec. 19	Hodson, G., M. Inst. C.E. ..	Loughborough. Abbey Buildings, Prince's Street, Westminster, S.W.
1896 Apr. 25 R1901 May 11	*Hogbin, L. W.	"Rowena," Preston Road, Leytonstone, N.E.
1890 Feb. 1	Holden, J., A.M. Inst. C.E.	Highway Surveyor to the Rural District Council, Llandaff. Ely, Cardiff.
1897 Jan. 16	Hole, W. P.	Borough Surveyor, Montgomery. Crowther's Hall, Welshpool.
1892 Mar. 11	Holmes, G. W., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Walthamstow, N.E.
1890 June 7	Holt, G. F.	48 Cecil Road, Upton Manor, E.
1901 Dec. 7	*Holt, W.	Surveyor to the Urban District Council, Sale, Cheshire.
1884 Oct. 9	Hooley, Cosmo C., Assoc. M. Inst. C.E.	Surveyor to the Rural District Council, Barton-upon-Irwell. Green Lane, Patricroft.
1884 Oct. 9	Hooley, E. P., A.M.Inst.C.E. (*Member of Council.*)	County Surveyor, Nottingham.
1898 Jan. 15	Hopkinson, F.	Surveyor to the Rural District Council, Blyth and Cuckney. 40 Bridge Street, Worksop.
1889 Sept. 21	Hopkinson, W. H., A.M.Inst. C.E. (*Member of Council.*)	Borough Engineer, Keighley; *Hon. Secretary*, Yorkshire District.
1891 Dec. 12	Horan, J., M.E., M.Inst.C.E.	County Surveyor, 82 George Street, Limerick, Ireland.
1895 July 27	Horsfall, W. H. D.	Surveyor to the Urban District Council, Southowram. 9 Harrison Road, Halifax.
1900 May 19	Horsfield, J. Nixon	Surveyor to the Urban District Council, Hampton Wick. Kingston-on-Thames.
1890 May 3	Horton, G. S.	Surveyor, Felixstowe.
1902 Sept. 6	Hoskins, M.	Surveyor to the Urban District Council, Oystermouth.
1894 Mar. 3	Howard, H.	Surveyor to the Urban District Council, Littlehampton.
1898 Sept. 3	Howard, S.	Surveyor to the Urban District Council, Bradford-on-Avon.
1889 Dec. 14 R1898 Oct. 15	Howard-Smith, W., Assoc. M. Inst. C.E.	"Naworth," Lanercost Road, Tulse Hill Park, S.W.
1880 May 27	Howcroft, J..	Surveyor to the Urban District Council, Redcar, Yorkshire.
1894 June 21	Howell, F. G.	County Surveyor, Surrey. Kingston-on-Thames.
1896 Feb. 22	Howse, W. T.	Surveyor to the Urban District Council, Bexley.
1897 June 17	Hughes, H. T.	Highway Surveyor, Hayfield Road, Chapel-en-le-Frith.
1897 Jan. 16	Humphreys, J.	Surveyor to the Urban District Council, Maesteg.
1899 June 1	Humphries, H. H.	Surveyor to the Urban District Council, Erdington.
1894 June 21	Hunt, G. J.	Borough Engineer, Dorchester.

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Date of Election and Transfer.		
1897 July 8	HUNTER, T.	Surveyor to the Urban District Council, Leigh.
c1891 Aug. 1 T1896 Apr. 25	*HURD, H.	Surveyor to the Urban District Council, Broadstairs.
c1901 Aug. 24 T1901 Dec. 7	*HUTTON, F.	Surveyor to the Urban District Council, Ashton-on-Mersey.
1898 Mar. 19	HUXLEY, J.	Surveyor to the Rural District Council, Hailsham.
1898 May 21	INGAMELLS, E. W...	Surveyor to the Urban District Council, Pokesdown.
c1895 Apr. 20 T1896 Oct. 24	*INGHAM, W., A.M. Inst.C.E.	Water Engineer, Torquay.
1899 Feb. 25	INGRAM, S.	County Surveyor, Devon. Exeter.
1888 Nov. 17	IRVING, W. E.	Surveyor to the Municipal Shire of Toowong, near Brisbane, Queensland.
1893 June 24 R1902 Nov. 8	ISAACS, L. H.	3 Verulam Buildings, Gray's Inn, W.C.
1900 July 19	JACK, G. H.	Surveyor to the Urban District Council, Aston Manor.
1893 Oct. 21	JAFFREY, W.	Town Surveyor, Matlock Bath.
1896 Oct. 24	JAMES, A. C., A.M. Inst. C.E.	Surveyor to the Urban District Council, Grays Thurrock. Grays.
1900 Mar. 10	JAMES, J. P.	Borough Surveyor, Tenby.
c1887 Oct. 22 T1890 Mar. 29	*JAMESON, M. W.	Borough Surveyor, Stepney. Gt. Alie St., Whitechapel, E.
1897 Feb. 13	JARVIS, R. W.	Surveyor to the Rural District Council, Tenbury.
1885 Apr. 18	JEEVES, E.	Surveyor to the Urban District Council, Melton Mowbray.
c1896 Jan. 18 T1896 Oct. 24	*JENKIN, C. J., A.M. Inst.C.E.	Surveyor to the Urban District Council, Walton-on-Thames.
1899 June 10	JENKINS, D. M., A.M.Inst.C.E.	Borough Surveyor, Neath.
1880 Feb. 7	JENNINGS, G.	Borough Surveyor, Rotherham.
1895 May 25	JEPSON, J.	Surveyor to the Urban District Council, Leveushulme.
1892 July 21	JEVONS, J. H., A.M. Inst. C.E.	Borough Surveyor, Hertford.
1895 June 27	JOHNSTON, J., Assoc. M. Inst. C.E.	Waterworks Engineer, Brighton.
1883 Aug. 4 R1902 Nov. 8	JONES, H.C., Lt.-Col. A. S., Assoc. M. Inst. C.E.	Ridge Cottage, Finchampstead, Berks.
1873 Feb. 15	JONES, C., M. Inst. C.E. (*Past President and General Hon. Secretary.*)	Borough Surveyor, Ealing, Middlesex.
1894 July 7	JONES, CHRISTOPHER	Borough Surveyor, Hythe, Kent.

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Date of Election and Transfer.		
1874 Jan. 29	JONES, I. M., M. Inst. C.E.	City Surveyor, Chester; Engineer to the Dee Bridge Commissioners.
1894 June 21	JONES, J. P.	Surveyor to the Rural District Council, Hengoed, *viâ* Cardiff.
1894 June 21	JONES, J. O.	Surveyor to the Rural District Council, Biggleswade.
1900 Mar. 10	JONES, T. C.	Surveyor to the Urban District Council, Redruth.
1892 May 28	JONES, W., Assoc.M.Inst.C.E.	Surveyor to the Urban District Council, Colwyn Bay.
1897 Feb. 13	JONES, W. J.	Surveyor to the Urban District Council, Rhondda.
1898 Apr. 23	JONES, W. P.	Surveyor to the Urban District Council, Glyncorrwg.
1891 June 25	JUKES, W. H.	Surveyor to the Urban District Council, Tipton.
1895 July 27 R1899 Dec. 16	KAY, W. R.	Athol Street, Douglas, Isle of Man.
1889 Feb. 9	KEMP, J., Assoc. M. Inst. C.E.	Engineer to the Municipality of Brisbane, Queensland.
1892 Apr. 23	KENNEDY, J. D.	Borough Surveyor, Retford.
1895 May 25	KEYWOOD, H. G.	Surveyor to the Rural District Council. Maldon.
1892 July 11	KIDD, T., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Swadlincote, Burton-on-Trent.
1899 Oct. 21	KILLICK, J. S.	Surveyor to the Rural District Council, Maidstone.
1899 June 29	KILLICK, P. G.	Borough Surveyor, Finsbury, E.C.
1902 May 10	KINNISON, A. M.	Highway Surveyor to the Rural District Council, Leek, Staffs.
1888 Sept. 15	KIRK, T., Assoc. M. Inst. C.E.	"Rushton," Lytton Road, East Brisbane, Queensland.
1892 Mar. 11	KIRKBY, S. A., M.A.	County Surveyor, Cork (South division), East Riding. Miramur, Queenstown.
1893 Oct. 19	KNAPP, R. W.	Borough Surveyor, Andover.
1894 Mar. 3	KNIGHT, J. M., A.M.Inst.C.E.	35 Bancroft Road, Mile End, E.
1884 Oct. 9	LACEY, F. W., M.Inst.C.E. ..	Borough Engineer, Bournemouth.
G1893 Jan. 14 T1895 Mar. 16	*LACEY, G. W.	Borough Surveyor, Oswestry.
1882 May 25 R1902 Jan. 25	LAFFAN, G. B., M. Inst. C.E.	Hardy's Chambers, Pietermaritzburg.
1900 Dec. 15	LAILEY, H. G. N.	Late Surveyor to the Urban District Council, Heysham.
1900 July 19	LAITHWAITE, V.	Surveyor to the Urban District Council, Turton.
1891 June 6	LANDLESS, J. T., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Brierfield, Lancs. Station Buildings, Nelson.
1894 June 21 R1902 Nov. 8	LATHAM, A., M. Inst. C.E. ..	Municipal Buildings, Margate.

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Date of Election and Transfer.			
1895	May 25	LAURENS, F., A.M. Inst. C.E.	Surveyor to the Rural District Council, Cookham. 23 St. Luke's Close, Maidenhead.
1882	Apr. 15	LAWS, W. G., M. Inst. C.E. (*Past President.*)	95 Osborne Road, Newcastle-on-Tyne.
1897	Jan. 16	LAWSON, A.W., A.M.Inst.C.E.	Borough Surveyor, Rawtenstall.
1884	July 10	LAWSON, C. G., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Southgate. District Offices, Palmer's Green, N.
1900	Mar. 10	LAWTON, C. H.	Surveyor to the Urban District Council, Warminster. Christchurch Cottage, Warminster, Wilts.
G1899 T1901	Oct. 21 May 11	*LEA, M.	City Surveyor, Truro.
1896	Oct. 24	LEEBODY, J. W.	County Surveyor, Co. Tyrone (S.)
1898	Mar. 19	LEETE, H. J. G	Market Hill, Ely, Cambs.
1880	Apr. 10	LEETE, W. H., A.M.Inst.C.E.	County Surveyor, Bedford.
1900	May 19	LEGG, E. I.	Borough Surveyor, Christchurch, Hants.
1894	May 19	LEIGH, W.	Borough Surveyor, Chorley.
1873	Feb. 15	LEMON, J., M. Inst. C.E. (*Past President.*)	Consulting Engineer, Southampton; and 11 Victoria Street, Westminster, S.W.
1899	Oct. 21	LINES, E.	Engineer to the Rural District Council, Chesterfield.
G1896 T1899	July 25 Dec. 16	*LIVERSEDGE, J. W.	Wigan Road, Ashton-in-Makerfield.
1891 R1901	Mar. 21 Aug. 24	LIVINGSTONE, G., Assoc. M. Inst. C.E.	17 Victoria Street, Westminster, S.W.
G1895 T1900	May 25 Oct. 15	*LOBLEY, F.	Town Surveyor, Hale, Cheshire.
1873	Feb. 15	LOBLEY, J., M. Inst. C.E. (*Past President.*) (*Member of Council.*)	Borough Engineer, Hanley, Staffordshire.
1896	June 25	LOCKE, W. R.	Borough Surveyor, Town Hall, Hemel Hempstead.
1889	Sept. 21	LOMAX, C. J., Assoc. M. Inst. C.E.	Engineer to the Urban District Council, Gorton. 37 Cross Street, Manchester.
1896	Oct. 24	LONGFIELD, R. W. F., Assoc. M. Inst. C.E.	County Surveyor, Co. Cork (W.). Bandon.
1902	Nov. 8	LORD, E. I.	Borough Engineer, Greymouth, New Zealand.
1901	May 11	LOVEDAY, W. F.	Borough Surveyor, Stoke Newington, N.
1892	Jan. 16	LOVEGROVE, E. J., M. Inst. C.E. (*Member of Council.*)	Engineer to the Urban District Council, Hornsey, N.
1887	June 18	LOWE, C. H., M. Inst. C.E. (*Past-President.*) (*Member of Council.*)	30 Somerset Street, Portman Square, W.
1897	July 8	LUMSDEN, J. L.	Burgh Surveyor, Kirkcaldy.
1896	July 25	LUND, C.	Surveyor to the Urban District Council, Cleckheaton.
1884	July 10	LUND, J...	Late Borough Surveyor, Bedford.
1896	Oct. 24	LYNAM, F. J., Assoc. M. Inst. C.E.	County Surveyor, Co. Tyrone (N.)
G1888 T1897	July 12 Oct. 16	*LYNAM, G. T., Assoc.M. Inst. C.E	Borough Surveyor, Burton-on-Trent.

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Date of Election and Transfer.		
1891 Aug. 1	LYNAM, P. J.	County Surveyor, Louth. Dundalk, Ireland.
1873 May 2 R1900 Mar. 10	McBEATH, A. G., Assoc. M. Inst. C.E.	Montagu Road, Sale, Cheshire.
1883 May 30	MacBRAIR. R. A., Assoc. M. Inst. C.E.	City Engineer, Lincoln.
1900 Feb. 10	McDERMID, C.	Surveyor to the Urban District Council, Eston.
1897 Feb. 13	McDONALD, A. B., M. Inst. C.E. (*Member of Council.*)	City Engineer, Glasgow.
1890 Oct. 18	MACDONALD, D. G., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Rugby.
1897 Jan. 16	MacKENZIE, D.	County Surveyor, Dunfermline.
1895 Oct. 19	McKENZIE, J. McD.	Surveyor to the Rural District Council, Bucklow. 7 Market Street, Altrincham.
1879 Oct. 23 R1889 Oct. 19	McKIE, H. U., M. Inst. C.E.	Riverdale, Ludlow, Salop.
1898 June 30	McKILLOP, R.	Burgh Surveyor, Perth, N.B.
1898 Feb. 19	MADIN, W. B.	Surveyor to the Urban District Council, Rushden.
1897 Mar. 13	MAGER, F. W.	Surveyor to the Rural District Council, Walsall.
1886 Dec. 18	MAIR, H., Assoc. M. Inst. C.E.	Borough Engineer, Hammersmith, W.
1900 Feb. 10	MALLINSON, J.	Surveyor to the Urban District Council, Skipton.
G1891 Jan. 21 T1897 June 19	*MANLEY, J.	Borough Surveyor, Wokingham.
1892 July 21	MANNING, G. W.	Surveyor to the Rural District Council, Staines.
G1898 Jan. 15 T1901 Aug. 24	*MARKS, C. W...	Surveyor to the Rural District Council, North-East Medene, Isle of Wight. "Brooklands," Wooton, Isle of Wight.
1888 July 12	MARKS, H. C., A. M. Inst. C.E.	City Surveyor, Carlisle.
1899 May 6	MARKS, W. L.	Surveyor to the Urban District Council, Rhyl.
1901 May 11	MARSH, F. G...	Surveyor to the Rural District Council, Mutford and Lothingland.
1897 Mar. 13	MARSHALL, J...	Surveyor to the Rural District Council, West Malling.
1891 Jan. 21 R1902 Nov. 8	MARSTON, C. F., Assoc. M. Inst. C.E.	44 High Street, Sutton Coldfield.
1894 Mar. 3	MARTEN, H. J., Assoc. M. Inst. C.E.	Borough Surveyor, Eastern District, Wandsworth. 215 High Road, Balham, S.W.
1890 Mar. 29 R1898 Mar. 19	MASON, C., Assoc. M. Inst. C.E.	Beeston, near Nottingham.
1899 May 6	MASON, C. G., Assoc. M. Inst. C.E.	Borough Surveyor, Guildford.
1890 Mar. 29	MASSIE, F., A.M. Inst. C.E.	Surveyor to the Rural District Council, Wakefield.
1883 Feb. 17	MATHEWS, G. S., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Dorking.

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Date of Election and Transfer.		
1898 Dec. 17	*Matthews, E. R.	Surveyor to the Urban District Council, Bridlington.
1881 Dec. 10	MAWBEY, E. G., M. Inst. C.E. (*Past President.*) (*Member of Council*).	Borough Engineer, Leicester.
1892 Mar. 11	Mawson, R. C.	Borough Surveyor, Evesham.
G1896 July 25 T1902 Sept. 6	*Maxwell, W. H., Assoc. M. Inst. C.E.	Borough Surveyor, Tunbridge Wells.
1883 June 28	MAY, F. J. C., M. Inst. C.E. (*Past President.*)	Borough Engineer and Surveyor, Brighton.
1894 Oct. 20	Maybury, H. P.	Surveyor to the Urban District Council, Great Malvern.
1901 Aug. 24	Maylan, S.	Surveyor to the Rural District Council, Basford.
1889 May 18	Mayne, C., M. Inst. C.E. ..	Engineer and Surveyor to the Municipal Council, Shanghai. *Hon. Corresponding Sec.* for Eastern Asia.
1883 Feb. 17	MEADE, T. DE COURCY, M. Inst. C.E. (*Past President.*)	City Surveyor, Manchester.
G1888 Jan. 14 T1894 Oct. 20 R1900 Apr. 21	*Mellor, T. E. W., Assoc. M. Inst. C.E.	Withington, Boyne Park, Tunbridge Wells.
1888 July 12	*Metcalf, J. W., Assoc. M. Inst. C.E.	Town Surveyor, Newmarket.
1890 June 7	Middleton, R. H., Assoc. M. Inst. C.E.	Borough Surveyor, Walsall.
1893 June 24	Miller, H., M. Inst. C.E. ..	County Surveyor, East Suffolk, Ipswich.
1902 July 10	Miller, H.	Surveyor to the Urban District Council, Heysham.
1893 June 24	Mills, J. H.	Surveyor to the Urban District Council, Crompton, near Oldham.
1897 Jan. 16	*Milnes, G. P., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Stroud.
1874 May 23	Mitchell, J.	Borough Surveyor, Hyde, Manchester.
1887 July 14	Molineux, W. F. Y.	Engineer and Surveyor to the Rural District Council, Ulverston.
1896 Oct. 24	Moncur, J., A.M. Inst. C.E.	County Highway Surveyor, Stafford.
1896 Jan. 18	Monson, H., A.M. Inst. C.E.	47 Victoria Street, Westminster, S.W.
1900 Dec. 15	Monteath, G.	County Surveyor, Newtown, St. Boswell's, N.B.
1891 Oct. 17	Moore, J. H.	County Surveyor, Co. Meath. 63 Eccles Street, Dublin.
1898 Apr. 23	Morgan, E. F.	Borough Road Surveyor, Croydon.
1895 July 27	Morgan, G. S.	Surveyor to the Rural District Council, Llantrissant, Glamorgan.
1892 July 11	Morgan, J.	Surveyor to the Rural District Council, Pontardawe. Swansea.

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Date of Election and Transfer.		
1901 June 8	MORGAN, R. P.	Surveyor to the Urban District Council, Towyn.
1874 May 1	MORGAN, W. D., Assoc. M. Inst. C.E.	Borough Surveyor, Weymouth and Melcombe Regis, Dorsetshire.
1898 June 30	MORRIS, F. J.	Borough Surveyor, Grantham.
1891 Aug. 1	MORTIMER, J.	Surveyor to the Urban District Council, Tettenhall, near Wolverhampton.
A1902 Jan. 25 T1902 June 7	*MOUNT, J. C., A.M. Inst. C.E.	Borough Surveyor, Lancaster.
1885 Feb. 7	MOUNTAIN, A. H., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Withington, near Manchester.
1901 Feb. 16	*MOYNIHAN, M. A.	Surveyor to the Urban District Council, Westport, Co. Mayo.
1898 Sept. 3	MULVANY, C. J., M. Inst. C.E.	County Surveyor, Roscommon.
1890 Mar. 29	MURCH, P.	Borough Engineer, Portsmouth.
1896 Nov. 28	MURPHY, P. E., Assoc. M. Inst. C.E.	Engineer to the Tottenham and Wood Green Joint Drainage Committee. 712 High Road, Tottenham, N.
1895 Feb. 16	MURZBAN, KHAN BAHADUR M. C., C.I.E., M. Inst. C.E.	Executive Engineer, Bombay.
1886 June 12	MYATT, J.	Town Surveyor, Leek.
1896 Oct. 24	NANKIVELL, H. H.	Surveyor to the Urban District Council, Braintree.
1894 Mar. 3	*NAYLOR, W., A.M. Inst. C.E.	16 Walton's Parade, Preston.
1893 July 31	*NETTLETON, H., Assoc. M. Inst C.E.	Surveyor to the Urban District Council, Weston-super-Mare.
1900 Feb. 10	NEWEY, W. F.	Surveyor to the Urban District Council, Nantwich.
1877 May 1	NEWMAN, F.	County Surveyor, Isle of Wight. Ryde.
1897 July 8	NEWMAN, S. J.	Surveyor to the Urban District Council, Branksome.
1897 Feb. 13	NEWTON, C. E.	17 Cooper Street, Manchester.
G1895 Jan. 19 TA1901 Oct. 19 TM1902 Mar. 22	*NEWTON, E. B., A.M. Inst. C.E.	Borough Surveyor, Paddington, W.
1891 Oct. 17	NEWTON, G. H.	Surveyor to the Urban District Council, Denton, Manchester.
1888 May 12	NEWTON, W. J., A.M. Inst. C.E.	Borough Surveyor, Accrington.
G1892 Sept. 24 T1899 Feb. 25	*NICHOLS, A. E., A.M. Inst. C.E.	Borough Engineer, Folkestone.
1887 July 14 R1899 Feb. 25	NORRINGTON, J. P., Assoc. M. Inst. C.E.	17 Victoria Street, Westminster, S.W.
G1897 Mar. 13 T1898 Sept. 3	*NORRIS, J. H.	Borough Surveyor, Godalming.
1886 Dec. 18 R1901 May 11	NORRISH, G. R.	Hawley House, Tudor Road, Upper Norwood.
1900 Dec. 15	NUTTALL, H.	Surveyor to the Urban District Council, Kearsley.
1899 Feb. 25	NUTTALL, W.	Surveyor to the Urban District Council, Prestwich.
G1898 June 30 T1899 Oct. 21	*OAKDEN, R.	Surveyor to the Rural District Council, Newark.

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Date of Election and Transfer.		
1901 Aug. 24	O'HARA, H.	Surveyor to the Urban District Council, Ballymena, Ireland.
1891 Aug. 1	ORCHARD, W. P., B.E.	County Surveyor, Ballina, North Mayo, Ireland.
1892 Jan. 16	OXTOBY, W., A.M. Inst. C.E.	Borough Engineer, Camberwell, S.E.
1896 July 25	*PALLISER, W. A.	Town Engineer, East London, Cape of Good Hope.
1896 Apr. 25	PALMER, F. W. J.	Surveyor to the Urban District Council. Herne Bay.
1900 Mar. 10	PALMER, P. H.	Borough Surveyor, Hastings.
1894 Apr. 6	PARDOE, J. C., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Barry, near Cardiff.
1876 May 1	PARKER, J., A.M. Inst. C.E.	City Surveyor, Hereford.
1887 July 14 r1895 June 27	PARKER, J., A.M. Inst. C.E.	107 Bedford Court Mansions, Bedford Square, W.C.
1896 Nov. 28	PARKER, J. E., A.M.Inst.C.E.	P.O. Chambers, St. Nicholas Square, Newcastle-on-Tyne.
1896 Oct. 24	PARKER, S. W.	Surveyor to the Urban District Council, Thornhill.
1893 July 13	PARR, F., Assoc. M. Inst. C.E.	Borough Surveyor, Bridgwater.
c1893 Jan. 14 r1894 Oct. 20	*PARR, N.	Surveyor to the Urban District Council, Brentford.
c1898 June 30 r1839 Oct. 21	*PARR, F. H.	Surveyor to the Urban District Council, Wealdstone.
1894 June 21	PATON, J. (*Member of Council.*)	Borough Engineer, Plymouth.
1895 Jan. 19	PATTISON, W. P.	Surveyor to the Urban District Council, Benwell and Fenham.
1897 Jan. 16	PEACOCK, T. J.	Surveyor to the Rural District Council, Spalding.
1898 Dec. 17	PEARCE, F. W.	Surveyor to the Urban District Council, Twickenham.
1894 Mar. 3	PEARSON, W. T.	Surveyor to the Urban District Council, Rothwell, Northants.
1897 Feb. 13	PEASE, C. R.	Borough Surveyor, Todmorden.
1899 Oct. 21	PEET, H. F.	City Engineer, Bloemfontein, South Africa.
1891 Dec. 12	PEIRCE, R., Assoc.M.Inst.C.E.	Municipal Engineer, Singapore.
1896 Nov. 28	PERRINS, B.	Surveyor to the Urban District Council, Redditch.
1891 Sept. 12	PERRY, J., M.E., M.Inst.C.E.	County Surveyor, Co. Galway (West Riding). Galway.
1898 May 21	PETCH, W. J.	Surveyor to the Urban District Council, Leigh-on-Sea, Essex.
1893 Apr. 22	PETREE, M., A.M. Inst. C.E.	10 Victoria Terrace, Jarrow-on-Tyne.
1889 May 18	PHILLIPS, R., A.M. Inst. C.E.	County Surveyor, Gloucester.
1901 Oct. 19	PICKARD, J. E.	Borough Surveyor, Pontefract, Yorks.
1901 Aug. 24	PICK, S. P.	County Surveyor, Leicester. 6 Millstone Lane, Leicester.
1898 Apr. 23	PICKER, E.	Surveyor to the Rural District Council, Beverley.
c1887 June 18 r1890 Sept. 13	*PICKERING, J. S., Assoc. M. Inst. C.E. (*Member of Council.*)	Surveyor to the Urban District Council, Nuneaton; *Hon. Secretary*, Midland District.

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Date of Election and Transfer.		
1881 Dec. 10 R1884 May 29	PICKERING, R.	11 Lowther Street, Whitehaven.
G1894 Jan. 13 T1895 Oct. 19	*PICKERING, S. A., A.M. Inst. C.E.	Borough Surveyor, Oldham.
G1894 Jan. 13 T1895 Oct. 19	*PICKLES, G. H., A.M.Inst.C.E.	Borough Surveyor, Burnley
1886 Sept. 11	PILDITCH, J. T.	Borough Engineer, Battersea, S.W.
1881 Dec. 10	PLATT, S. S., M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Rochdale.
1893 Oct. 21	PLOWRIGHT, A. H...	Borough Engineer, Wisbech, Cambs.
1884 Mar. 15 R1885 Oct. 3	POLLARD, J., M. Inst. C.E. ..	31 Old Queen Street, Westminster, S.W.
1897 July 8	POOLE, H. C.	Surveyor to the Urban District Council, Wath-upon-Dearn.
1881 July 7	PORTER, R.	Borough Surveyor, Wakefield.
1899 Jan. 21 R1901 May 11	POWELL, J.	4–6 Victoria Chambers, Terminus Street, East London, Cape Colony.
1902 Feb. 22	POWELL, J. G.	Surveyor to the Rural District Council, Godstone, Surrey.
1891 Sept. 12	PRATT, R.	Borough Surveyor, Henley-on-Thames.
1899 Oct. 21	*PRESCOTT, A. E.	Borough Surveyor, Douglas, Isle of Man.
1898 Mar. 19	PRESCOTT, W. H.	Surveyor to the Urban District Council, Tottenham, N.
1892 Jan. 16	PRESS, W. J.	Surveyor to the Urban District Council, Burnham, Somerset.
G1894 June 21 T1899 June 29	*PRICE, A. J.	Surveyor to the Urban District Council, Lytham.
1879 May 1	PRICE, J., M. Inst. C.E. (*Member of Council.*)	City Surveyor, Birmingham.
1899 June 10	PRIESTLEY, C. H.	Corporation Water Engineer, Cardiff.
1873 May 2	PROCTOR, J., M. Inst. C.E. ..	Mere Lawn, Bolton, Lancashire.
1897 Feb. 13	PROFFITT, J. T.	Surveyor to the Urban District Council, Worsley, Walkden, Bolton.
1892 May 28	PROUSE, O. M., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Ilfracombe.
1900 Oct. 15	PULLAR, W. M.	Shire Engineer, Coburg, Victoria.
1873 May 2	PURNELL, E. J.	Water Engineer, Coventry, Warwickshire.
1899 May 6	PURSER, W. B.	County Surveyor, West Sussex. Horsham.
G1893 July 31 T1898 June 13	*PUTMAN, W. E., A. M. Inst. C.E.	Borough Surveyor, Morley.
1897 May 15	PYM-JONES, I.	City Surveyor, Chichester.
1886 Dec. 18 R1901 Oct. 19	RADFORD, J. C., A. M. Inst. C.E.	163 Upper Richmond Road, Putney, S.W.
1889 July 4	RAPLEY, W.	Surveyor to the Rural District Council, Dorking.
1898 Apr. 23	RAYNER, F. J.	Surveyor to the Urban District Council, Newhaven.

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Date of Election and Transfer.		
1878 May 1	READ, R., A.M. Inst. C.E. ..	City Surveyor, Gloucester.
1899 May 6	REES, E.	Surveyor to the Urban District Council, Pontypridd.
1898 Dec. 17	REID, R. M.	Highway Surveyor to the Stirlingshire County Council, 46 Barnton Street, Stirling.
1902 Jan. 25	REID, S., Assoc. M. Inst. C.E.	Municipal Engineer, Penang, S.S.
1897 Feb. 13	RENWICK, R.	Surveyor to the Urban District Council, Horsham.
1892 Mar. 11	REYNOLDS, E. J., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Friern Barnet.
1888 July 12 R1902 Feb. 22	RICHARDS, R. W., Assoc. M. Inst. C.E.	Mutual Life of N.Y. Building, Martin Place, Sydney.
1888 May 12	RICHARDSON, H., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Handsworth.
1884 Oct. 9	RICHARDSON, J.	Surveyor to the Urban District Council, Stamford.
1895 Apr. 20	RICHARDSON, R.	Surveyor to the Urban District Council, Malton.
1901 May 11	*RIDLER, W.	Borough Surveyor, Tewkesbury.
1892 Mar. 11	RIDOUT, A. R.	Surveyor to the Urban District Council, Stone.
1896 Nov. 28	ROBERTS, D.	Borough Surveyor, Lewes.
G1891 Dec. 12 T1897 Mar. 13	*ROBERTS, F., A. M. Inst.C.E.	Borough Engineer, Worthing.
1893 Jan. 14	ROBINSON, A. R.	Surveyor to the Urban District Council, Clacton-on-Sea.
1891 Oct. 17	ROBINSON, W. P.	Surveyor to the Urban District Council, Skelton-in-Cleveland.
1886 May 1	ROBINSON, W. J.	City Surveyor, Londonderry.
1876 May 1	ROBSON, O. C., M. Inst. C.E. (*Past President.*) (*Member of Council.*)	Surveyor to the Urban District Council, Willesden, Middlesex.
1896 Mar. 21	RODWELL, A.	Surveyor to the Rural District Council, Skipton.
1896 Jan. 18	ROGERS, W. E.	Surveyor to the Urban District Council, Rugely.
1895 Jan. 19	ROSS, John C., A.M. Inst. C.E.	Town Engineer, Warrnambool, Victoria, Australia.
1892 July 11	ROTHERA, F. B.	Surveyor to the Urban District Council, Featherstone.
1880 Oct. 2	ROUNTHWAITE, R. S., Assoc. M. Inst. C.E.	City Engineer, Wellington, New Zealand.
1893 July 13	ROWLAND, J.	155 Church Lane, Old Charlton, Kent.
1873 May 2 R1902 Nov. 8	ROYLE, H., Assoc. M. Inst. C.E.	12 Kensington Road, Ansdell, Lytham, Lancashire.
1888 May 12	RUCK, F. W.	County Surveyor, Kent. Maidstone.
1895 Feb. 16	RUSHBROOKE, T. J.	Borough Surveyor, High Wycombe.
1896 Apr. 25	*RUSHTON, E.	Surveyor to the Urban District Council, Cleethorpes.
1880 June 23	SADLER, G. W.	467 High Street, Cheltenham.

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Date of Election and Transfer.		
1890 Mar. 29	*Saise, A. J., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Kingswood, Bristol. Ventnor House, Forest Road, Fishponds, Bristol.
1899 Feb. 25	Salkield, T.	Surveyor to the Urban District Council, Leatherhead.
1889 May 18	Sasse, G. H.	Borough Surveyor, Chelmsford.
G1887 June 18 T1898 May 21	*Saunders, J.	Arcade Chambers, Newark.
1884 Oct. 9	Savage, W. H., A.M.Inst.C.E.	"Montfichet," East Ham, E.
1894 Mar. 3	Saville, J.	Town Surveyor, Heckmondwike.
1889 May 6	Schofield, W. H.	County Surveyor, Lancashire. County Hall, Preston.
1894 June 21	Scorgie, N., A.M. Inst. C.E.	Borough Surveyor, Hackney, N.E.
1892 Sept. 24	Scott, A. F.	Surveyor to the Urban District Council, Cromer.
1888 Nov. 17	Scott, H. H., A.M.Inst.C.E.	Engineer to the Commissioners, Hove.
1901 Aug. 24	Scott, J. H.	Surveyor to the Urban District Council, Winton, Bournemouth.
1880 May 27	Scott, R. S., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Bishop's Stortford.
1897 Feb. 13	Scott, T.	Surveyor to the Rural District Council, Tadcaster.
1897 July 8	Senior, C. E.	Surveyor to the Urban District Council, Neston, Cheshire.
1896 Oct. 24	Senior, J. S.	Surveyor to the Urban District Council, Swanage.
G1894 July 7 T1898 Mar. 19	*Settle, J. A., A.M.Inst.C.E.	Borough Engineer and Surveyor, Heywood, Manchester.
1873 Feb. 15	Sharman, E.	Surveyor to the Urban District Council, Wellingborough, Northamptonshire.
1896 Nov. 28	Sharpe, J. E.	Surveyor to the Urban District Council, Otley.
1891 June 6	Shaw, H., Assoc.M.Inst.C.E.	Surveyor to the Urban District Council, Ilford.
1890 June 7 R1901 Aug. 24	Shaw, J. H.	Shenstone Cottage, Brownhills, Staffs.
1892 May 28	Sheard, W. C., Assoc.M. Inst. C.E.	Surveyor to the Urban District Council, Heaton Norris, Stockport.
1891 Oct. 17	Shepherd, G. J.	Surveyor to the Rural District Council, Kidderminster.
1884 June 10	Sheppard, G.	Borough Surveyor, Newark.
1892 July 11	Shillington, H., M.E. ..	Town Surveyor, Lurgan, Ireland.
1895 Oct. 19	Shipton, T. H.	Surveyor to the Urban District Council, Oldbury.
1902 June 7	Siddalls, J.	Borough Surveyor, Tiverton.
1887 Oct. 22	Siddons, J. M.	Surveyor, Oundle.
1896 Jan. 18	Sidwell, H. T.	Surveyor to the Rural District Council, Rochford, Essex.
1887 July 14 R1898 Oct. 15	*Silcock, E. J., M. Inst. C.E.	10 Park Row, Leeds.
1897 Mar. 13	Silcock, H.	Surveyor to the Rural District Council, Blackwell Mansfield.

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Date of Election and Transfer.		
1901 Feb. 16	SIMPSON, H. F.	County Surveyor, Northern Division, Isle of Ely. Wisbech.
1891 Aug. 1 / R1895 June 27	SIMPSON, W. H., A. M. Inst. C.E.	Horsefair Street, Leicester.
1890 Sept. 13	SINCLAIR, J.S., A.M.Inst.C.E.	Borough Surveyor, Widnes.
1895 Oct. 19	SKELTON, R., A.M. Inst. C.E.	Municipal Engineer, Colombo, Ceylon.
1899 Oct. 21	SLOCOMBE, D. W.	Surveyor to the Urban District Council, Brynmawr.
1898 Oct. 15	SMAIL, J. M.	Chief Engineer to the Metropolitan Board of Works, Sydney, N.S.W.
1898 June 30	SMALES, J. E.	Surveyor to the Urban District Council, Ware.
1895 June 27	SMILLIE, J. F.	Borough Surveyor, Tynemouth.
1899 Dec. 16	SMITH, ARTHUR	Borough Surveyor, Dartmouth.
1892 Mar. 11	SMITH, C. CHAMBERS	Surveyor to the Urban District Council, Sutton, Surrey.
1902 Sept. 6	SMITH, F. H.	Surveyor to the Urban District Council, Portishead.
1899 Mar. 25	SMITH, H. W.	Borough Engineer, Scarborough.
1892 Mar. 11	SMITH, J., Assoc. M. Inst. C.E.	County Surveyor, Co. Galway (E. Riding), Ballinasloe.
1897 May 15	SMITH, J.	Borough Surveyor, Buckingham.
1895 May 25	SMITH, J. B.	Surveyor to the Urban District Council, Tyldesley.
1893 July 13	SMITH, J. C., A.M. Inst. C.E.	Borough Surveyor, Bury St. Edmunds.
1899 Oct. 21	SMITH, J. D.	County Road Surveyor, Wigtownshire. 1 Newton Terrace, Stranraer.
1901 Dec. 7	SMITH, J. GOULD, A.M. Inst. C.E.	Borough Surveyor, Beverley.
1879 May 1	SMITH, J. W. M. (*Member of Council.*)	Borough Surveyor, Wrexham, Denbighshire. *Hon. Secretary*, North Wales District.
1891 Dec. 12	SMITH, T. R., A.M. Inst. C.E.	Surveyor to the Urban District Council, Kettering.
1897 Jan. 16	SMITH, V.	Surveyor to the Urban District Council, Teignmouth.
1888 Jan. 14 / T1897 Mar. 13	*SMITH-SAVILLE, R. W., Assoc. M. Inst. C.E.	Borough Surveyor, Darwen.
1887 Sept. 13	SMYTHE, F.	Surveyor to the Urban District Council, Finchley, N.
1898 Jan. 15	SNELL, J., A.M. Inst. C.E. ..	Borough Electrical Engineer, Sunderland.
1898 Dec. 17	SPENCER, J.	Surveyor to the Urban District Council, Oakworth. York Chambers, Cooke Street, Keighley.
1873 May 2 / R1881 Dec. 10	SPENCER, J. P., A.M.Inst.C.E.	13 Grainger Street West, Newcastle-on-Tyne.
1902 May 10	SPENCER, L. G.	Borough Surveyor, Melrose, Wellington, New Zealand. 90 Constable Street, Newtown, Wellington, New Zealand.
1885 June 25 / R1888 Sept. 15	SPINKS, W., M. Inst.C.E. ..	39 Prudential Assurance Buildings, Park Row, Leeds.
1880 Feb. 7 / R1899 June 10	STAINTHORPE, T.W., A.M.Inst. C.E.	Sewerage Works, Totnes, Devon.

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Date of Election and Transfer.		
1889 Dec. 14	STALLARD, S., A.M. Inst. C.E.	Highway Surveyor to the Rural District Council, Croydon. Town Hall, Croydon.
1898 June 30	STANSFIELD-BRUN, J.	Borough Surveyor, Lymington.
1892 July 21 / R1900 Apr. 21	STEAD, S.	33 James Street, Harrogate.
1892 Mar. 11	STEPHENSON, E. P., Assoc. M. Inst. C.E.	Town Surveyor, Llandudno.
1886 July 8	STEVENS, G.	Surveyor to the Urban District Council, Abercarn, Mon.
1890 Mar. 29	STEVENS, L.	Surveyor to the Urban District Council, Newton Abbott, Devon.
1892 Mar. 11	STEVENSON, A.	District Surveyor, Ayrshire County Council.
1891 Oct. 17	STEVENSON, J.	Surveyor to the Urban District Council, East Molesey.
1901 Feb. 16	STEWART, J.	Surveyor to the Urban District Council, Leighton Buzzard.
1891 June 25	STICKLAND, E. A., Assoc. M. Inst. C.E.	Borough Surveyor, Windsor.
1897 Jan. 16	STILGOE, H. E., A.M.Inst.C.E.	Borough Engineer and Surveyor, Dover.
1895 Feb. 16	STIRRAT, J.	Municipal Engineer, Rangoon.
1900 Dec. 15	STIVEN, E. E.	Borough Surveyor, Whitehaven.
1887 Sept. 17	STOKOE, J.	Surveyor to the Urban District Council, Altrincham.
1898 Mar. 19	STOW, J. F.	Surveyor to the Rural District Council, Uxbridge.
G1893 June 24 / T1893 July 13	*STRINGFELLOW, W., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Eastleigh, Hants.
1880 May 27	STUBBS, W., A.M. Inst. C.E.	Borough Engineer, Blackburn.
G1892 July 11 / T1892 Sept. 24	*SUMNER, F., A.M. Inst. C.E.	Borough Engineer, Woolwich.
1895 Mar. 16	*SURTEES, R. T.	Water Engineer to the Urban District Council, Newton-in-Makerfield. Newton-le-Willows, Lancs.
G1899 June 29 / T1901 June 27	*SWALES, T. R.	Borough Surveyor, Maldon.
1880 June 23 / R1889 Apr. 13	SWARBRICK, J., M. Inst. C.E.	30 St. Anns Street, Manchester.
1899 June 10	SYKES, M. H.	Borough Surveyor, Stockton-on-Tees.
1887 Mar. 12	TANNER, W.	County Surveyor, Monmouthshire. Newport.
1895 Mar. 16	TARBIT, T. H.	Surveyor to the Urban District Council, Loftus, Yorkshire.
1891 Mar. 21	TAYLOR, H. W., Assoc. M. Inst. C.E.	St. Nicholas Chambers, Amon Corner, Newcastle-on-Tyne.
1890 Sept. 13	TAYLOR, T. G.	Borough Surveyor, Ramsgate.
G1891 Sept. 12 / T1897 Oct. 16	*TAYLOR, W. J., Assoc. M. Inst. C.E.	County Surveyor, Hants. Winchester.
1892 Apr. 23	TERRILL, W.	Surveyor to the Urban District Council, Ashford, Kent.
1901 Feb. 16	*THOMAS, R. A.	Surveyor to the Urban District Council, Menai Bridge.
1892 Mar. 11	*THOMAS, R. J., M. Inst. C.E. (*Member of Council.*)	County Surveyor, Bucks. Aylesbury. *Hon. Secretary*, Home District.

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Date of Election and Transfer.		
1890 May 3	THOMAS, T. J., A.M.Inst.C.E.	Surveyor to the Urban District Council, Ebbw Vale.
1902 May 10	THOMAS, W. B.	Surveyor to the Urban District Council, Southwick-on-Wear.
1887 Sept. 17	THOMAS, W. E. C., A.M. Inst. C.E. (*Member of Council.*)	Surveyor to the Rural District Council, Neath: *Hon. Secretary.* South Wales District.
1891 Jan. 21	THORPE, J.	Surveyor to the Rural District Council, Macclesfield.
1898 Jan. 15	THROPP, J.	County Surveyor, Lincolnshire. 29 Broadgate, Lincoln.
1898 Apr. 23	THWAITES, W., M. Inst. C.E.	Chief Engineer to the Metropolitan Board of Works, Melbourne, Australia.
G1891 June 6 T1893 Oct. 21	*TOMES, G. B., A.M. Inst. C.E.	Surveyor to the Urban District Council, Barnes, Mortlake.
1898 Apr. 23	TOMLINSON, S.	1 Raffles Place, Singapore.
1895 Mar. 16	TOOLEY, H.	Surveyor to the Urban District Council, Buckhurst Hill, Essex.
1890 May 3	TOWLSON, S., A.M. Inst. C.E.	Surveyor to the Urban District Council, Sevenoaks.
1894 Oct. 20	TRAVERS, W. H.	Surveyor to the Urban District Council. Wallasey.
1897 Jan. 16	TRESSIDER, W. H.	Borough Surveyor, Falmouth.
1897 Feb. 13	TRINDER, C. D. M.	Surveyor to the Rural District Council, Claypole, Newark.
1901 Feb. 16	TROWSDALE, T. J.	Surveyor to the Urban District Council, Annfield Plain, Co. Durham.
1893 Oct. 21	TURLEY, A. C., A.M.Inst.C.E.	City Engineer, Canterbury.
1897 Mar. 13	TURNER, H. H.	Surveyor to the Rural District Council, Limehurst, Lancs. 2 Grace Street, Old Square, Ashton-under-Lyne.
1899 June 10	*TURNER, S.	Surveyor to the Urban District Council, Knaresborough, Yorkshire.
1898 June 30	TURRIFF, A. A.	Burgh Surveyor, Elgin, N.B.
1889 Sept. 21	VALLANCE, R. F.	Borough Surveyor, Mansfield.
1887 Oct. 22	VALON, W. A. McINTOSH, Assoc. M. Inst. C.E.	Ramsgate Corporation Gasworks Engineer. 140 and 141 Temple Chambers, Temple Avenue, E.C.
1901 Mar. 23	VAWSER, C.	Surveyor to the Urban District Council. Cheriton, near Folkestone.
G1894 Jan. 13 T1901 Dec. 7	*VEIT, L. J.	Surveyor to the Urban District Council, Goole.
1889 Sept. 21	VENTRIS, A., Assoc. M. Inst. C.E.	"Campton," Arkwright Road, Hampstead, N.W.
1897 June 19	VINCENT, S. J. L.	Borough Surveyor, Newbury.
1894 June 21	WADDINGTON, J. A. P., Assoc. M. Inst. C.E.	Borough Engineer, Marylebone, W.
1902 June 7	WAKEFORD, J. P.	Surveyor to the Urban District Council, Bilston.

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Date of Election and Transfer.		
1888 July 12	WAKELAM, H. T., M. Inst. C.E. (*Member of Council.*)	County Surveyor, Middlesex. Guildhall, Westminster, S.W.
1898 Sept. 3	WALKER, A. H.	Borough Surveyor, Loughborough.
1873 May 2	WALKER, T., M. Inst. C.E. ..	Borough Surveyor, Croydon, Surrey.
1889 July 4	WALLACE, G.	Borough Engineer, Holborn, E.C.
1887 June 18	WALSHAW, J. W.	Borough Surveyor, Peterborough.
1899 Jan. 21	WARD, J.	Borough Engineer, Derby.
1886 July 8	WARDLE, J. W., A.M.Inst.C.E.	Borough Surveyor, Longton.
1890 May 3	WATERHOUSE, D.	Surveyor to the Urban District Council, Watford.
1892 Mar. 11	WATKEYS, G., A.M.Inst.C.E.	Surveyor to the Urban District Council, Llanelly.
1887 June 18	WATSON, J. D., Assoc. M. Inst. C.E.	Engineer to the Birmingham, Tame and Rea Drainage Board, Council House, Birmingham.
1889 Sept. 21	WATTS, E. T.	Surveyor to the Rural District Council, Bishop's Stortford.
1893 Oct. 21	WATTS, W.	Water Engineer, Langsett, near Penistone.
1899 Jan. 21	WEAVER, H. J.	Borough Surveyor, King's Lynn.
1887 June 18	WEAVER, W., M. Inst. C.E. (*Vice-President.*)	Borough Engineer, Kensington, W.
1900 Oct. 15	WEBB, H.	Surveyor to the Urban District Council, Halstead, Essex.
1897 Feb. 13	WEBB, J. A.	Surveyor to the Rural District Council, Hendon. Great Stanmore.
1901 Oct. 19	WEBSTER, J. W.	Surveyor to the Urban District Council, Cowes, Isle of Wight.
1895 May 25 / R1901 Aug. 24	WEBSTER, R. J.	District Surveyor, Castleton, Manchester.
1882 Apr. 15	WELBURN, W.	Borough Surveyor, Middleton, near Manchester.
1887 June 18	WESTON, G.	The Limes, Pinner, near Harrow.
1889 Apr. 13	WESTON, H. J., Assoc. M. Inst. C.E.	24 Portland Street, Southampton.
1893 Apr. 22	WETHERILL, J. W.	Borough Surveyor, Richmond, Yorks.
1887 Feb. 5 / R1902 Mar. 22	WHEELER, G. R. W., Assoc. M. Inst. C.E.	47 Victoria Street, Westminster, S.W.
1891 Oct. 17	WHITBREAD, R.	Surveyor to the Urban District Council, Carlton, Notts.
1888 July 12	WHITE, A. E., M. Inst. C.E. ..	City Engineer, Hull.
1891 Oct. 17	WHITE, H. V., M. Inst. C.E. I.	County Surveyor, Queen's County. Ballybrophy.
1900 Mar. 10	WHITE, J. N.	Borough Surveyor, Stalybridge.
1873 May 2	WHITE, W. H., M. Inst. C.E. (*Past President.*)	City Engineer, Oxford.
1899 Mar. 25	WHITTELL, F. S.	Surveyor to the Urban District Council, Worksop.
1900 Aug. 25	WHYATT, H. G. A. M. Inst. C.E.	Borough Engineer, Great Grimsby.

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Date of Election and Transfer.		
1889 Feb. 9	WIKE, C. F., M. Inst. C.E. (*Member of Council.*)	City Surveyor, Sheffield.
1888 May 12	WILD, G. H.	Surveyor to the Urban District Council, Littleborough, near Manchester.
1896 Apr. 25	WILDING, J.	Surveyor to the Urban District Council, Runcorn.
1884 May 29 R1902 Nov. 8	WILKINSON, J. P.	47 and 48 Arcade Chambers, St. Mary's Gate, Manchester.
1899 Feb. 25	WILKINSON, W.	Ashton House, Hemingbrough, E. Yorks.
1899 Mar. 25	WILKINSON, M. H.	Surveyor to the Urban District Council, Leyland.
1884 Oct. 9 R1885 June 6	WILLCOX, J. E., Assoc. M. Inst. C.E.	63 Temple Row, Birmingham.
1894 Mar. 3	WILLIAMS, H. DAWKIN	Surveyor to the Urban District Council, Ogmore and Garrw, Blackmill R.S.O., Bridgend.
1893 July 31	WILLIAMS, J. B.	Borough Surveyor, Daventry.
1893 Oct. 24	WILLIAMS, J.	Surveyor to the Urban District Council, Mountain Ash.
1897 May 15	WILLIAMS, M.	Surveyor to the Urban District Council, Bridgend.
1891 June 25	WILLMOT, J.	County Surveyor, Warwickshire. 6 Waterloo Street, Birmingham.
1898 June 30	WILSON, A.	County Surveyor, Dumbartonshire.
1887 Sept. 17	WILSON, G.	Surveyor to the Urban District Council, Alnwick.
1873 May 2 R1899 Feb. 25	WILSON, J.	Bankside, Bacup, Lancashire.
1884 May 29	*WILSON, J. B., A.M. Inst. C.E.	Surveyor to the Rural District Council, Cockermouth.
1900 Feb. 10	WILSON, V.	Surveyor to the Urban District Council, Wardle.
1887 May 7	WINDOW, E. R., Assoc. M. Inst. C.E.	2 Church Street, Liverpool.
1897 Oct. 16	WINNING, D.	Burgh Surveyor, Broughty Ferry, N.B.
1880 Oct. 2	WINSHIP, G., A.M. Inst. C.E.	Borough Surveyor, Abingdon, Berks.
1896 Feb. 22	WINTER, O. E., Assoc. M. Inst. C.E.	Borough Surveyor, Hampstead, N.W.
G1900 May 19 TA1902 Jan. 25 TM1902 Nov. 8	*WOLFENDEN, B. J., A.M. Inst. C.E.	Borough Engineer, Bootle.
1880 Feb. 7	WOOD, A. R.	Surveyor to the Urban District Council, Tunstall.
1894 Mar. 3	WOOD, F. J., A. M. Inst. C.E.	County Surveyor, Sussex East. Lewes.
1898 Apr. 23	WOOD, W. E.	Surveyor to the Urban District Council, Church.
1900 Feb. 10	WOODS, E. L.	Town Surveyor, Bangor, Co. Down.
1885 Oct. 3	WOODBRIDGE, C. A.	Surveyor, Pinner, Middlesex.
1899 May 6	WOODWARD, F.	Surveyor to the Urban District Council, Stourbridge.

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Date of Election and Transfer.		
1897 July 8	*Worrall, E.	Surveyor to the Urban District Council, Penmaenmawr.
886 July 8	Worth, J. E., M. Inst. C.E.	District Engineer, London County Council, Spring Gardens, S.W.
G1900 July 19 T1901 Oct. 19	*Wootton, A. S.	Borough Surveyor, South Molton, Devon.
G1893 July 13 T1899 Oct. 21	*Wright, J. A.	Surveyor to the Urban District Council, Horfield.
1892 May 28	Wynne-Roberts, R. O., Assoc. M. Inst. C.E.	City Hydraulic Engineer, Cape Town.
1895 Jan. 19	YABBICOM, T. H., M.Inst. C.E. (*President.*)	City Engineer, Bristol.
G1892 July 11 T1892 Sept. 24	*Yates, F. S., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Waterloo, near Liverpool.
1894 June 21	York, H., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, East Barnet Valley. Station Road, New Barnet.
1900 May 19	Young, J.	Borough Surveyor, Ayr.
1899 Dec. 16	Young, T.	Surveyor to the Rural District Council, Sunderland.
1900 May 19	Young, W. P...	Surveyor to the Urban District Council, Hoyland Nether.

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TOWNS AND DISTRICTS

REPRESENTED BY MEMBERS OF THE ASSOCIATION.

H. *signifies*	HOME DISTRICT.	West *signifies*	WESTERN DISTRICT.
Met. „	METROPOLITAN DISTRICT.	N. „	NORTHERN DISTRICT.
M. „	MIDLAND DISTRICT.	E. „	EASTERN DISTRICT.
Y. „	YORKSHIRE DISTRICT.	W. „	WELSH DISTRICT.
L. & C. „	LANCASHIRE AND CHESHIRE DISTRICT.	I. „	IRISH DISTRICT.
		A. „	ABROAD.

TOWN.	DISTRICT.	NAME.
ABERCARNE	West.	G. Stevens.
ABERDEEN	N.	W. Dyack.
ABERGAVENNY	West.	J. Haigh.
ABERSYCHAN	W.	E. Cooke.
ABINGDON	H.	G. Whiship.
ABRAM	L. & C.	G. Heaton.
ACCRINGTON	L. & C.	W. J. Newton.
ACTON	H.	D. J. Ebbetts.
ALDEBURGH	E.	J. C. Gordon.
ALDERSHOT	H.	N. F. Dennis.
ALNWICK	N.	G. Wilson.
ALTRINCHAM	L. & C.	J. Stokoe.
ANDOVER	H.	R. W. Knapp.
ANNFIELD PLAIN	N.	T. J. Trowsdale.
ANTRIM (County)	I.	J. H. Brett.
ARMAGH	I.	J. C. Boyle.
ARMAGH (County)	I.	R. H. Dorman.
ASHFORD	H.	W. Terrill.
ASHTON-UNDER-LYNE	L. & C.	J. T. Earnshaw.
ASHTON-ON-MERSEY	L. & C.	F. Hutton.
ASTON MANOR	M.	G. H. Jack.
ATHERTON	L. & C.	W. Clough.
„	L. & C.	F. H. Grimshaw.
AUDLEY	M.	T. Bibbey.
AYLESBURY	H.	J. H. Bradford
AYR	N.	J. Young.
AYRSHIRE (County)	N.	A. Stevenson.
BALLYMENA	I.	H. O'Hara.
BANBURY	H.	N. H. Dawson.
BANGOR (Co. DOWN)	I.	E. L. Woods.
BARKING	H.	C. F. Dawson
BARNES	H.	G. B. Tomes.

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TOWN.	DISTRICT.	NAME.
Barry	W.	J. C. Pardoe
Barton-upon-Irwell (Rural)	L. & C.	C. C. Hooley.
Basford (Rural)	M.	S. Maylan.
Basingstoke	H.	G. Fitton.
„ (Rural)	H.	R. Forrester.
Battersea	Met.	J. T. Pilditch.
Beckenham	H.	J. A. Angell.
Bedford (County)	H.	W. H. Leete.
Bedlingtonshire	N.	C. Brown.
Belfast	I.	J. C. Bretland.
Belper	M.	T. Fenn.
„ (Rural)	M.	R. C. Cordon.
Benwell	N.	W. P. Pattison.
Bermondsey	Met.	R. J. Angel.
Berwick-on-Tweed	N.	R. Dickinson.
Bethnal Green	Met.	F. W. Barratt.
Beverley	Y.	J. G. Smith.
„ (Rural)	Y.	E. Picker.
Bexhill	H.	G. Ball.
Bexley	H.	W. T. Howse.
Biddulph	M.	S. Gibson.
Biggleswade	H.	T. Cockrill.
„ (Rural)	H.	J. O. Jones.
Bilston	M.	J. P. Wakeford.
Birkenhead	L. & C.	C. Brownridge.
Birmingham	M.	J. Price.
Bishop's Castle	M.	A. Hamar.
Bishop's Stortford	H.	R. S. Scott.
„ „ (Rural)	H.	E. T. Watts.
Blackburn	L. & C.	W. Stubbs.
Blackpool	L. & C.	J. S. Brodie.
Blackwell (Rural)	M.	H. Silcock.
Bloemfontein (South Africa)	A.	H. F. Peet.
Blyth and Cuckney (Rural)	M.	F. Hopkinson.
Bognor	H.	O. A. Bridges.
Bombay	A.	M. C. Murzban.
Bootle	L. & C.	B. J. Wolfenden.
Bournemouth	H.	F. W. Lacey.
Brackley	M.	A. A. Green.
Bradford	Y.	J. H. Cox.
Bradford-on-Avon	West	S. Howard.
Braintree	E.	H. H. Nankivell.
Branksome	West.	S. J. Newman.
Bray	I.	P. F. Comber.
Brentford	H.	N. Parr.
Brentwood	E.	J. E. Fothergill.
Bridgend	W.	M. Williams.
Bridgwater	West.	F. Parr.
Bridlington	Y.	E. R. Matthews.
Brierfield	L. & C.	J. T. Landless.
Brighton	H.	F. J. C. May.
Brisbane (Queensland)	A.	J. Kemp.
Bristol	West.	T. H. Yabbicom.
Briton Ferry	W.	H. A. Clarke.
Broadstairs	H.	H. Hurd.
Bromyard	M.	J. D. Barrs.
Broughty Ferry, N.B.	N.	D. Winning.
Brownhills	M.	W. B. Chancellor.
Brynmawr	W.	D. W. Slocombe.
Buckhurst Hill	E.	H. Tooley.

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TOWN.	DISTRICT.	NAME.
Buckingham	M.	J. Smith.
„ (County)	H.	R. J. Thomas.
Bucklow (Rural)	L. & C.	J. McD. McKenzie.
Burnham	West.	W. J. Press.
Burnley	L. & C.	G. H. Pickles.
„ (Rural)	L. & C.	S. Edmondson.
Bushlem	M.	F. Bettany.
Burton-on-Trent	M.	G. T Lynam.
Bury St. Edmunds	E.	J. C. Smith.
Buxton	M.	W. H. Grieves.
Caerphilly	W.	A. O. Harpur.
Calcutta	A.	T. C. Deverell.
Camberwell	Met.	W. Oxtoby.
Cannock (Staffs)	M.	J. S. Hendry.
Canterbury	H.	A. C. Turley.
Cape Town, S.A.	A.	J. Cook.
Cardiff	W.	W. Harpur.
Carlisle	N.	H. C. Marks.
Carlton	M.	R. Whitbread.
Carnarvonshire (County)	W.	E. Evans.
„ (Borough)	W.	E. Hall.
Castleford	Y.	W. Green.
Caversham	H.	S. P. Andrews.
Chadderton	L. & C.	W. Eckersley.
Chatham	H.	C. Day.
Chelmsford	E.	G. H. Sasse.
„ (Rural)	E.	J. Dewhirst.
Chelsea	Met.	T. W. E. Higgens.
Cheltenham	West.	J. Hall.
Chepstow	W.	F. Feather.
Cheriton	H.	C. Vawser.
Chertsey	H.	J. F. Stow.
Chesham	H.	P. C. Dormer.
Cheshire (County)	L. & C.	H. F. Bull.
Cheshunt	H.	R. H. Jeffes.
Chester	L. & C.	I. M. Jones.
Chesterfield (Rural)	M.	E. Lines.
Chesterton (Rural)	E.	J. Dunn.
Chichester	H.	I. Pym-Jones.
Chorley	L. & C.	W. Leigh.
Christchurch	H.	E. I. Legg.
Church	L. & C.	W. E. Wood.
Clacton-on-Sea	E.	A. R. Robinson.
Clayton-le-Moors	L. & C.	A. Dodgeon.
Claypole (Rural)	E.	C. D. M. Trinder.
Cleckheaton	Y.	C. Lund.
Clethorpes	E.	E. Rushton.
Coalville	M.	L. L. Baldwin.
Coburg (Victoria)	A.	W. M. Pullar.
Cockermouth (Rural)	N.	J. B. Wilson.
Colchester	E.	H. Goodyear
Colne	L. & C.	T. H. Hartley.
Colombo (Ceylon)	A.	F. A. Cooper.
„ „	A.	R. Skelton.
Colwyn Bay	W.	W. Jones.

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TOWN.	DISTRICT.	NAME.
Congleton	L. & C.	R. Burslam.
Cookham (Rural)	H.	F. Laurens.
Cork	I.	H. A. Cutler.
„ (County), West	I.	R. W. Longfield.
„ „ South	I.	S. A. Kirkby.
Cottingham	Y.	J. H. Hanson.
Cowes (Isle of Wight)	H.	J. W. Webster.
Cowpen	N.	R. Grieves.
Crewe	L. & C.	G. Eaton-Shore.
Cromer	E.	A. F. Scott.
Crompton	L. & C.	J. H. Mills.
Croydon	H.	T. Walker.
„ (Highways)	H.	E. F. Morgan.
„ (Rural) (Highways)	H.	S. Stallard.
„ (Rural)	H.	R. M. Chart.
Cumberland (County)	N.	G. J. Bell.
Cupar (Fife) (County)	N.	T. Aitken.
Dartford	H.	W. Harston.
Dartmouth	West.	A. Smith.
Daventry	M.	J. B. Williams.
Darwen	L. & C.	R. W. Smith-Saville.
Deal	H.	T. C. Golder.
Denton	L. & C.	G. H. Newton.
Derby	M.	J. Ward.
„ (County)	M.	J. S. Story.
Desborough	M.	D. J. Diver.
Devon (County)	West.	W. Ingham.
Dewsbury	Y.	H. Dearden.
Doncaster (Rural) (Highways)	Y.	W. Crabtree.
„ (Rural)	Y.	C. C. Barras.
Dorchester	West.	G. J. Hunt.
Dorking	H.	G. S. Mathews.
„ (Rural)	H.	W. Rapley.
Douglas (Isle of Man)	L. & C.	A. E. Prescott.
Dover	H.	H. E. Stilgoe.
Down (County)	I.	J. Heron.
Driffield (Rural)	Y.	T. C. Beaumont.
Droitwich	M.	T. P. Baylis.
Droylsden	L. & C.	C. Hall.
Dublin	I.	S. Harty.
„ (County)	I.	W. Collen.
Dudley	M.	J. Gammage.
Dukinfield	L. & C.	S. Hague.
Dumbartonshire (County)	N.	A. Wilson.
Dunfermline (County)	N.	D. MacKenzie.
„	N.	A. W. Bell.
Durham (Rural)	N.	G. Gregson.
Ealing	H.	C. Jones.
East Barnet Valley	H.	H. York.
East Ham	H.	A. H. Campbell.
East London (Cape Colony)	A.	W. A. Palliser.
Eastleigh	H.	W. Stringfellow.
East Molesey	H.	J. Stevenson.
East Stonehouse	West.	A. W. Debnam.
East Stow (Rural)	E.	G. F. P. Harrison.

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TOWN.	DISTRICT.	NAME.
East Retford (Rural)	M.	T. Henry.
Ebbw Vale	W.	T. J. Thomas.
Elgin, N.B.	N.	A. A. Turriff.
Enfield	H.	R. Collins.
Epsom	H.	E. R. Capon.
Erdington	M.	H. H. Humphries.
Erith	H.	H. Hind.
Eston	Y.	C. McDermid.
Etos (Rural)	H.	R. Hallam.
Eton (Rural) (Highways)	H.	A. Gladwell.
Evesham	M.	R. C. Mawson.
Exeter	West.	D. Cameron.
Exmouth	West.	W. D. Harding.
Falmouth	West.	W. H. Tressider.
Farebam	H.	W Butler.
Farnborough	H.	J. E. Hargreaves.
Farnham	H.	R. W. Cass.
Featherstone	Y.	F. B. Rothera.
Fenny Stratford	H.	J. Chadwick.
Fermanagh	I.	J. P. Burkitt.
Finchley	H.	F. Smythe.
Finsbury	Met.	P. G. Killick.
Folkestone	H.	A. E. Nichols.
Foot's Cray	H.	W. A. Farnham.
Friern Barnet	H.	E. J. Reynolds.
Frome	West.	P. Edinger.
Gainsborough	E.	R. W. Fraser.
Galway (County), West	I.	J. Perry.
„ „ East	I.	J. Smith.
Glamorgan (County)	W.	T. L. Edwards.
Glasgow	N.	A. B. McDonald.
Glastonbury	West.	G. Alves.
Gloucester	West.	R. Reed.
„ (County)	West.	R. Phillips.
Glyncorrwg	W.	W. P. Jones.
Godalming	H.	J. H. Norris.
Godstone (Rural)	H.	J. G. Powell.
Goole	Y.	L. J. Veit.
Gorton	L. & C.	C. J. Lomax.
Gosforth	N.	C. J. Baff.
Gosport and Alverstoke	H.	H. Frost.
Grantham	E.	F. J. Morris.
Gravesend	H.	F. T. Grant.
Grays Thurrock	H.	A. C. James.
Great Crosby	L. & C.	W. Hall.
Great Grimsby	E.	H. G. Whyatt.
Great Yarmouth	E.	J. W. Cockrill.
Grey County (New Zealand) ..	A.	J. Higgins.
Greymouth (New Zealand) ..	A.	E. I. Lord.
Guernsey	H.	T. J. Guilbert.
Guildford	H.	C. G. Mason.
„ (Rural)	H.	J Anstee.
Guiseley	Y.	J. C. Haller.

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TOWN.	DISTRICT.	NAME.
Hackney	Met.	N. Scorgie.
Hailsham (Rural)	H.	J. Huxley.
Hale	L. & C.	F. Lobley.
Halifax (Rural)	Y.	F. Gordon.
Halstead	E.	H. Webb.
Hammersmith	Met.	H. Mair.
Hampstead	Met.	O. E. Winter.
Hampton Wick	H.	J. N. Horsfield.
Handsworth	M.	H. Richardson.
Hanley	M.	J. Lobley.
Hants (County)	H.	W. J. Taylor.
Hanwell	H.	S. W. J. Barnes.
Harrow	H.	J. P. Bennetts.
Harwich	E.	H. Ditcham.
Haslingden	L. & C.	J. S. Green.
Hastings	H.	P. H. Palmer.
Hawthorn (Victoria, Australia)	A.	H. T. Haynes.
Hayward's Heath	H.	H. W. Bowen.
Heaton Norris	L. & C.	W. C. Sheard.
Hebden Bridge	Y.	W. Calvert.
Heckmondwike	Y.	J. Saville.
Hemel Hempstead	M.	W. R. Locke.
Henlon	H.	S. S. Grimley.
„ (Rural)	H.	J. A. Webb.
Hengoed *viâ* Cardiff (Rural)	W	J. P. Jones.
Henley-on-Thames	H.	R. Pratt.
Hereford	M.	J. Parker.
„ (County)	M.	A. Dryland.
Herne Bay	H.	F. W. J. Palmer.
Hertford	H.	J. H. Jevons.
Heysham	L. & C.	H. Miller.
Heywood	L. & C.	J. A. Settle.
High Wycombe	H.	T. J. Rushbrooke.
Hinckley	M.	F. C. Cook.
Holborn	Met.	G. Wallace.
Holyhead	W.	A. Asquith.
Horfield	West.	J. A. Wright.
Hornsey	H.	E. J. Lovegrove.
Horsham	H.	R. Renwick.
Hove	H.	H. H. Scott.
Howrah (Bengal)	A.	A. Hale.
Hoylake and West Kirby	L. & C.	T. Foster.
Hoyland Nether	Y.	W. P. Young.
Huddersfield	Y.	K. F. Campbell.
„ (Gas)	Y.	E. A. Harman.
Hull	Y.	A. E. White.
Hyde	L. & C.	J. Mitchell.
Hythe	H.	Chris. Jones.
Ilford	E.	H. Shaw.
Ilfracombe	West.	O. M. Prouse.
Ipswich	E.	E. Buckham.
Isle of Thanet (Rural)	H.	F. T. Elliott.
Isle of Ely (N.) (County)	E.	H. F. Simpson.
Isle of Wight (County)	H.	F. Newman.
Islington	Met.	J. P. Barber.
Itchen	H.	T. A. Collingwood.

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TOWN.	DISTRICT.	NAME.
Kearsley	L. & C.	H. Nuttall.
Keighley	Y.	W. H. Hopkinson.
Kendal	N.	R. H. Clucas.
Kensington	Met.	W. Weaver.
Kent (County)	H.	F. W. Ruck.
Keswick	N.	W. Hodgson.
Kettering	M.	T. R. Smith.
Keyesham (Rural)	West.	H. M. Bennett.
Kidderminster (Rural)	M.	A. Comber.
Kilkenny (County)	I.	A. M. Burden.
King's Lynn	E.	H. J. Weaver.
Kingston (Highways)	H.	A. J. Henderson.
King's Norton	M.	A. W. Cross.
Kingston (Jamaica)	A.	C. V. Abrahams.
Kingswood	West.	A. J. Saise
Kirkcaldy	N.	J. L. Lumsden.
Knaresborough	Y.	S. Turner.

Lancashire (County)	L. & C.	W. H. Schofield.
Lancaster	L. & C.	J. C. Mount.
Lanchester (Rural) (Highways)	N.	W. Cumming.
Leatherhead	H.	T. Salkield.
Leeds	Y.	T. Hewson.
Leek	M.	J. Myatt.
„ (Rural) (Highways)	M.	A. M. Kinnison.
Leicester	M.	E. G. Mawbey.
„ (County)	M.	S. P. Pick.
Leigh	L. & C.	T. Hunter.
„ (Rural)	L. & C.	T. W. B. Gent.
Leigh-on-Sea	E.	W. J. Petch.
Leighton Buzzard	H.	J. Stewart.
Leith	N.	W. Beatson.
Leitrim (County)	I.	E. O'N. Clarke.
Levenshulme	L. & C.	J. Jephson.
Lewes	H.	D. Roberts.
Leyland	L. & C.	W. H. Wilkinson.
Leyton	H.	W. Dawson.
Limehurst (Rural)	L. & C.	H. H. Turner.
Limerick (County)	I.	J. Horan.
Lincoln	E.	R. A. MacBrair.
„ (County)	E.	J. Thropp.
Littleborough	L. & C.	G. H. Wild.
Littlehampton	H.	H. Howard.
Liverpool	L. & C.	J. A. Brodie.
Llandaff (Rural) (Highways)	W.	J. Holden.
Llandudno	W.	E. P. Stephenson.
Llanelly	W.	G. Watkeys.
Llantrissant (Rural)	W.	G. S. Morgan.
Loftus	Y.	T. H. Tarbit.
Londonderry	I.	W. J. Robinson.
Long Crendon (Rural)	H.	A. J. Dickinson.
Longford (County)	I.	J. W. Gunnis.
Longton	M.	J. W. Wardle.
Loughborough	M.	A. H. Walker.
Louth (County)	I.	P. J. Lynam.
Lower Bebington	L. & C.	H. W. Corrie.
Lowestoft	E.	G. H. Hamby.

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TOWN.	DISTRICT.	NAME.
Lurgan	I.	H. Shillington.
Luton	H.	A. J. L. Evans.
Lymington	H.	J. Stansfield-Brun.
Lynton	West.	W. H. Chowins.
Lytham	L. & C.	A. J. Price.
Macclesfield	L. & C.	E. E. Adshead.
„ (Rural)	L. & C.	J. Thorpe.
Maesteg	W.	J. Humphreys.
Maidstone	H.	T. F. Bunting.
„ (Rural)	H.	J. S. Killick.
Maldon	E.	T. R. Swales.
„ (Rural)	E.	H. G. Keywood.
Malton	Y.	R. Richardson.
Malvern	M.	H. P. Maybury.
Manchester	L. & C.	T. De C. Meade.
Mansfield	M.	R. F. Vallance.
Mansfield Woodhouse	M.	F. P. Cook.
Margam, Port Talbot	W.	J. Cox.
Margate	H.	E. A. Borg.
Market Harborough	M.	H. G. Coales.
Marylebone	Met.	J. A. P. Waddington
Matlock	M.	J. Diggle.
Matlock Bath	M.	W. Jaffrey.
Meath (County)	I.	J. H. Moore.
Melbourne	A.	W. Thwaites.
Melrose (N.Z.)	A.	L. G. Spencer.
Melton Mowbray	M.	E. Jeeves.
Menai Bridge	W.	R. A. Thomas.
Merthyr Tydvil	W.	T. F. Harvey.
Methley	Y.	T. W. Nichols.
Mexborough	Y.	G. F. Carter.
Middlesbrough	Y.	F. Baker.
Middlesex (County)	H.	H. T. Wakelam.
Middleton	L. & C.	W. Welburn.
Midhurst (Rural)	H.	A. G. Gibbs.
Midsomer Norton	West.	W. F. Bird.
Milton-next-Sittingbourne	H.	A. R. Warren.
Monmouthshire (County)	W.	W. Tanner.
Montgomery	W.	W. P. Hole.
Morley	Y.	W. E. Putman.
Mountain Ash	W.	J. Williams.
Mutford & Lothingland (Rural)	E.	F. G. Marsh.
Nantwich	L. & C.	W. F. Newey.
Nantyglo & Blaina	W.	W. J. Davies.
Neath	W.	D. M. Jenkins.
„ (Rural)	W.	W. E. C. Thomas.
Nelson	L. & C.	B. Ball.
Neston	L. & C.	C. E. Senior.
New Swindon	H.	H. J. Hamp.
Newark	M.	G. Sheppard.
„ (Rural)	M.	R. Oakden.
Newburn-on-Tyne	N.	T. Gregory.
Newbury	H.	S. J. L. Vincent.
Newcastle-on-Tyne	N.	F. J. Edge.
Newhaven	H.	F. J. Rayner.

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TOWN.	DISTRICT.	NAME.
Newmarket	E.	J. W. Metcalf.
Newport (Mon.)	West.	R. H. Haynes.
Newton Abbot	West.	L. Stevens.
Newtown St. Boswells, N.B.	N.	G. Monteath.
Norfolk (County)	E.	T. H. B. Heslop.
North East Medene, I.W. (Rural)	H.	C. W. Marks.
North Mayo (County)	I.	W. P. Orchard.
Northallerton	Y.	D. Hincheliffe.
Northwich	L. & C.	J. Brooke.
Norwich	E.	A. E. Collins.
Nottingham	M.	A. Brown.
" (County)	M.	E. P. Hooley.
Nuneaton	M.	J. S. Pickering.
Oakworth	Y.	J. Spencer.
Ogmore and Garew	W.	H. D. Williams.
Okehampton	West.	H. Geen.
Oldbury	M.	T. H. Shipton.
Oldham	L. & C.	S. A. Pickering.
Oswestry	M.	G. W. Lacey.
Otley	Y.	J. E. Sharp.
Oxford	H.	W. H. White.
Oystermouth	W.	M. Hoskins.
Paddington	Met.	E. B. Newton.
Padiham	L. & C.	J. Gregson.
Partick	N.	J. Bryce.
Peebles (County)	N.	R. S. Anderson.
Pemberton	L. & C.	G. Heaton.
Penang (Straits Settlements)	A.	S. Reid.
Penarth	W.	E. I. Evans.
Penmaenmawr	W.	E. Worrall.
Perry Barr	M.	H. H. Gammell.
Perth, N.B.	N.	R. McKillop.
Peterborough	M.	J. W. Walshaw.
Plymouth	West.	J. Paton.
Pontesdown	H.	E. W. Ingamells.
Pontardawe (Rural)	W.	J. Morgan.
Pontefract	Y.	J. E. Pickard.
Pontypridd	W.	E. Rees.
Poole	West.	J. Elford.
Port Elizabeth (South Africa)	A.	A. S. Butterworth.
Portishead	West.	F. H. Smith.
Portslade-by-Sea	H.	A. T. Allen.
Portland	West.	E. J. Elford.
Portsmouth	H.	P. Murch.
Prescot	L. & C.	W. Goldsworth.
Prestwich	L. & C.	W. Nuttall.
Queen's County	I.	H. V. White.
Queenstown (South Africa)	A.	W. A. Pallisor.

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TOWN.	DISTRICT.	NAME.
Ramsgate	H.	T. G. Taylor.
Rangoon	A.	J. Stirrat.
Rawtenstall	L. & C.	A. W. Lawson.
Redditch	M.	B. Perrins.
Redcar	Y.	J. Howcroft.
Redruth	West.	T. C. Jones.
Reigate	H.	F. T. Clayton.
Retford	M.	J. D. Kennedy.
Rhondda	W.	W. J. Jones.
Rhymney	W.	W. L. Marks.
Richmond (Surrey)	H.	J. H. Brierley.
Richmond (Yorks)	Y.	J. W. Wetherill.
Ripon	Y.	W. Edson.
Rochdale	L. & C.	S. S. Platt.
Rochester	H.	W. Banks.
Rochford (Rural)	H.	H. T. Sidwell.
Romford (Rural)	E.	E. G. Boden.
Roscommon (County)	I.	C. J. Mulvany.
Rotherham	Y.	G. Jennings.
„ (Rural)	Y.	B. Godfrey.
Rothwell (Northants)	M.	W. T. Pearson.
Rowley Regis	M.	W. H. Brettell.
Rugby	M.	D. G. MacDonald.
Rugeley	M.	W. E. Rogers.
Runcorn	L. & C.	J. Wilding.
„ (Rural)	L. & C.	W. Diggle.
Rushden	M.	W. B. Madin.
Ryton-on-Tyne	N.	J. P. Dalton.
St. Albans	H.	G. Ford.
St. Helen's (Lancs.)	L. & C.	G. J. C. Broom.
„ (Isle of Wight)	H.	J. I. Barton.
St. Neots (Hunts)	L.	A. T. Blood.
St. Pancras	Met.	W. N. Blair.
Saffron Walden	E.	A. H. Forbes.
Sale	L. & C.	W. Holt.
Salford	L. & C.	J. Corbett.
Saltburn-by-the-Sea	Y.	G. S. L. Bains.
Sandgate	H.	A. R. Bowles.
Scarborough	Y.	H. W. Smith.
Sevenoaks	H.	S. Towlson.
Shanghai (China)	A.	C. Mayne.
Shanklin	H.	E. C. Cooper.
Sheffield	Y.	C. F. Wike.
Sherborne	West.	T. Farrall.
Shoreditch	Met.	J. R. Dixon.
Shrewsbury	M.	W. C. Eddowes.
Shropshire (County)	M.	A. T. Davis.
Singapore	A.	R. Peirce.
Skelton-in-Cleveland	Y.	W. P. Robinson.
Skipton	Y.	J. Mallinson.
„ (Rural)	Y.	A. Rodwell.
Sleaford	E.	J. Clare.
Slough	H.	W. W. Cooper.
Smallthorne	M.	J. Deane.
Smethwick	M.	C. J. Fox-Allin.
Soothill Upper	Y.	J. Blackburn.
Solihull (Rural)	M.	A. E. Currall.

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TOWN.	DISTRICT.	NAME.
South Shields	N.	S. E. Burgess.
Southall Norwood	H.	H. R. Felkin.
Southampton	H.	J. A. Crowther.
Southend-on-Sea	H.	A. Fidler.
Southgate	H.	C. G. Lawson.
Southowram	Y.	W. H. D. Horsfall.
South Molton	West.	A. S. Wootton.
Southport	L. & C.	R. P. Hirst.
Southwark	Met.	A. Harrison.
Southwick-on-Wear	N.	W. B. Thomas.
Southwold	E.	F. Ball.
Spalding (Rural)	E.	T. J. Peacock.
Spilsby (Rural)	E.	T. A. Busbridge.
Stafford	M.	W. Blackshaw.
Stafford (County) (Highways)	M.	J. Moncur.
Staines	H.	E. J. Barrett.
„ (Rural)	H.	G. W. Manning.
Stalybridge	L. & C.	J. N. White.
Stamford	E.	J. Richardson.
Stepney	Met.	M. W. Jameson.
Stirling	N.	A. H. Gondie.
Stirlingshire (Highways)	N.	R. M. Reid.
Stockport	L. & C.	J. Atkinson.
Stockton-on-Tees	N.	M. H. Sykes.
Stoke-on-Trent	M.	A. Burton.
Stoke Newington	Met.	W. F. Loveday.
Stone	M.	A. R. Ridout.
Stourbridge	M.	F. Woodward.
Stratford-on-Avon	M.	R. Dixon.
Strood (Rural)	H.	W. Brooke.
Stroud	West.	G. P. Milnes.
Sudbury (Suffolk)	E.	T. W. A. Hayward.
Suffolk (County), East	E.	H. Miller.
Sunbury-on-Thames	H.	H. F. Coales.
Sunderland (Rural)	N.	T. Young.
Surrey (County)	H.	F. G. Howell.
Sussex (County), East	H.	F. J. Wood.
„ (County), West	H.	W. B. Purser.
Sutton	H.	C. C. Smith.
Sutton Coldfield	M.	W. A. H. Clarry.
Sutton-in-Ashfield	M.	McW. Bishop.
Swadlincote	M.	T. Kidd.
Swanage	West.	J. S. Senior.
Swansea	W.	G. Bell.
Swinton	L. & C.	H. Entwisle.
Sydney (New South Wales)	A.	J. M. Smail.
Tadcaster (Rural)	Y.	T. Scott.
Tamworth	M.	F. E. G. Bradshaw.
„ (Rural)	M.	H. J. Clarson.
Tanfield	N.	R. Heslop.
Teddington	H.	M. Hainsworth.
Teignmouth	West.	V. Smith.
Tenbury (Rural)	M.	R. W. Jarvis.
Tenby	W.	J. P. James.
Tettenhall	M.	J. Mortimer.
Tewkesbury	West.	W. Ridler.

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TOWN.	DISTRICT.	NAME.
Thornhill	Y.	S. W. Parker.
Tientsin (China)	A.	A.W.H. Bellingham.
Tipperary (County), South	I.	E. A. Hackett.
Tipton	M.	W. H. Jukes.
Tiverton	West.	J. Siddalls.
Todmorden	L. & C.	C. R. Pease.
Tonbridge	H.	W. L. Bradley.
"	H.	A. F. Ginn.
" (Rural)	H.	F. Harris.
Toowong (Queensland)	A.	W. E. Irving.
Tokio Fu (Japan)	A.	R. Hara.
Tottenham	H.	W. H. Prescott.
Towyn	W.	R. P. Morgan.
Truro	West.	M. Lea.
Tunbridge Wells	H.	W. H. Maxwell.
Tunstall	M.	A. R. Wood.
Turton	L. & C.	V. Laithwaite.
Twickenham	H.	F. W. Pearce.
Tyldesley	L. & C.	J. B. Smith.
Tynemouth	N.	J. F. Smillie.
Tyrone (County) North	I.	F. J. Lynam.
" " South	I.	J. W. Leebody.
Urmston	L. & C.	J. Heath.
Uxbridge (Rural) (Highways)	H.	E. Birks.
" (Rural)	H.	J. F. Stow
Ulverston (Rural)	L. & C.	W. F. Y. Molineux.
Wakefield	Y.	R. Porter.
" (Rural)	Y.	F. Massie.
Wallasey	L. & C.	W. H. Travers.
Walsall	M.	R. H. Middleton.
" (Rural)	M.	F. W. Mager.
Walthamstow	H.	G. W. Holmes.
Walton-on-Thames	H.	C. J. Jenkin.
Wandsworth (Eastern)	Met.	H. J. Marten.
" (Western)	Met.	P. Dodd.
Wanstead	H.	J. T. Bressey.
Wantage (Rural)	H.	W. Hanson.
Wardle	L. & C.	V. Wilson.
Ware	H.	J. E. Smales.
Warminster	West.	C. H. Lawton.
Warwickshire (County)	M.	J. Willmot.
Warrnambool (Melbourne)	A.	J. C. Ross.
Waterford	I.	M. J. Fleming.
" (County)	I.	W. E. L. Duffin.
Waterloo	L. & C.	F. S. Yates.
Watford	H.	D. Waterhouse.
Wath-upon-Dearne	Y.	H. C. Poole.
Wealdstone	H.	F. H. Parr.
Wellingborough	M.	E. Sharman.
Wellington (New Zealand)	A.	R. S. Rounthwaite.
Wembley	H.	C. R. W. Chapman.
West Bromwich	M.	A. D. Greatorex.

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TOWN.	DISTRICT.	NAME.
West Hartlepool	N.	J. W. Brown.
West Malling (Rural)	H.	J. Marshall.
Westminster	Met.	J. W. Bradley.
Weston-super-Mare	West.	H. Nettleton.
Westport (Co. Mayo)	I.	M. A. Moynihan.
Weymouth and Melcombe Regis	West.	W. B. Morgan.
Whitehaven	N.	E. E. Stiven.
Whitworth	L. & C.	T. Biker.
Widnes	L. & C.	J. S. Sinclair.
Westownshire (Highways) ..	N.	J. D. Smith.
Willenhall	M.	T. E. Fellows.
Willesden	H.	O. C. Robson.
Wellington Quay	N.	J. F. Davidson.
Wilmslow	L. & C.	A. S. Cartwright.
Wimbledon	H.	C. H. Cooper.
Winchester	H.	W. V. Anderson.
„ (Rural)	H.	G. E. Carter.
Windermere	L. & C.	C. E. Hines.
Windsor	H.	E. A. Stickland.
Wirton	H.	J. H. Scott.
Wisbech	E.	A. H. Plowright.
Withington	L. & C.	A. H. Mountain.
Witney	H.	G. A. Graham.
Wokingham	M.	J. Manley.
Wolverhampton	M.	G. Green.
Wood Green	H.	C. J. Gunyon.
Woodford	E.	W. Farrington.
Woollahra (Sydney)	A.	J. I. Haycroft.
Woolwich	M.	F. Sumner.
Worcester	M.	T. Caink.
„ (County)	M.	J. H. Garrett.
Worksop	M.	F. S. Whittell.
Worsley	L. & C.	J. T. Proffitt.
Worthing	H.	F. Roberts.
Wortley (Rural)	Y.	G. E. Beaumont.
Wrexham	W.	J. W. M. Smith.
„ (Rural)	W.	J. P. Evans.
Yeovil	W.	W. K. L. Armytage.
York	Y.	A. Creer.
Yorkshire, East Riding	Y.	A. Beaumont.
„ West Riding	Y.	J. V. Edwards.
„	Y.	W. G. Bryning.

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ASSOCIATES.

** Those Associates against whose names a star is placed have obtained the certificate of the Association.*

Date of Election and Transfer.			
1901	Oct. 19	ASHBEE, W.	Divisional Surveyor, Middlesex C.C. Briarside, Hanwell, W.
1902	Jan. 25	*BELL, L. M., A.M. Inst. C.E.	Assistant Engineer, Municipal Offices, Singapore, S.S.
1897	July 31	*BENTLEY, J. H., A. M. Inst.	Chief Engineering Assistant,
T1901	Oct. 19	C.E.	Town Hall, Oldham.
1898	June 30	*BEST, H. Storr	Assistant Engineer, Council
T1901	Oct. 19		Offices, Beckenham, S.E.
G1893	June 24	*BIRCH, J.	Deputy Surveyor, Public Offices,
T1902	Nov. 8		East Ham.
1897	June 9	*BISSELL, W. S.	Assistant Borough Surveyor,
T1901	Dec. 7		Wolverhampton.
1898	June 30	*BOWE, D. J.	Chief Assistant, Borough En-
T1901	Dec. 7		gineer's Office, Eastbourne.
1902	Jan. 25	BROOKES, A. E.	Assistant County Surveyor, Worcester C.C. Breedon Cross, King's Norton, Birmingham.
1902	Jan. 25	BROWN, H. A.	Assistant Borough Surveyor, Town Hall, Fulham, S.W.
1899	Jun. 29	*BUSH, W. E., ...	District Building Surveyor,
T1902	Jan. 25		Council House, Birmingham.
1892	July 11	*CARTER, G. F.	Deputy Borough Engineer,
T1901	Dec. 7		Croydon.
1895	May 25	*CLARK, A. H. F.	District Engineer, P.W.D.,
T1902	May 10		Ceylon.
1902	May 10	CLARK, G. E.	District Surveyor, Town Hall, Sheffield.
1890	Sept. 13	*CATCHPOLE, H.	Chief Assistant Engineer,
T1902	Sept. 6		Council Offices, Finchley.
1898	Dec. 17	*CLEWS, C. A.	Chief Assistant, Borough Sur-
T1902	Mar. 22		veyor's Office, Derby.
1900	May 19	*COOMBS, C. A.	Engineering Assistant, Town
T1901	Oct. 19		Hall, Burton-on-Trent.
1899	June 29	*COLLINGE, T. P.	Engineering Assistant, Town
T1902	Jan. 25		Hall, Nelson.
1897	Feb. 13	*COLLIS-ADAMSON, A. C. ..	Engineering Assistant, Council
T1901	Oct. 19		Offices, Hornsey, N.
G1899	Oct. 21	*COWAN, G.	District Surveyor, Town Hall,
T1902	Nov. 8		Portsmouth.
1901	Aug. 24	*COX, A. L.	Deputy Borough Engineer,
T1901	Oct. 19		Folkestone. Richmond House, Surrenden Road, Folkestone.
1901	Oct. 19	*CROXFORD, C. H.	Chief Engineering Assistant, Town Hall, Wood Green, N.
1902	Jan. 25	CROOK, W. E.	Chief Engineering Assistant, Middlesex C.C. Guildhall, Westminster.
1891	Sept. 12	*DOLAMORE, F. P.	Deputy Borough Engineer,
T1902	Sept. 6		Bournemouth.

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Date of Election and Transfer.		
1898 Dec. 17 †1901 Dec. 7	*Ellison, D.	Deputy Borough Engineer, West Bromwich.
1898 Feb. 19 †1902 Jan. 25	*Endsor, H. A.	Surveyor, R.D.C., St. Faiths. 110 Rosebery Road, St. Clement's Hill, Norwich.
1896 June 25 †1901 Dec. 7	*Fell, P. O.	Deputy City Engineer, Norwich.
1901 June 8 †1901 Oct. 19	*Fowlds, W., A.M. Inst. C.E.	Chief Assistant, Borough Engineer's Office, Keighley.
1901 May 11 †1902 Jan. 25	*Gair, J.	Assistant Borough Surveyor, Town Hall, Hammersmith, W.
1899 Dec. 16 †1902 May 10	*Goodfellow, H.	Chief Engineering Assistant, Town Hall, Southport.
1894 Jan. 13 †1902 July 10	*Gordon, J., A.M. Inst. C.E.	Assistant Burgh Surveyor, Town House, Aberdeen.
1901 Dec. 7	Greenshields, N., A.M. Inst. C.E.	Borough Engineer, Bedford.
1893 Jan. 14 †1901 Oct. 19	*Greenwood, J. P., A.M. Inst. C.E.	Deputy Borough Surveyor, Town Hall, Burnley.
1902 Mar. 22	Hadfield, W. J.	Chief Assistant, Town Hall, Sheffield.
1897 June 19 †1901 Oct. 19	*Haigh, W. H., A.M. Inst. C.E.	Engineering Assistant, Borough Engineer's Office, Town Hall, Cardiff.
1899 Oct. 21 †1902 May 10	*Harper, A.	Deputy Borough Surveyor, Town Hall, St. Helen's, Lancs.
1892 May 28 †1902 Jan. 25	*Hills, H. J., A.M. Inst. C.E.	Assistant Borough Surveyor, Town Hall, Shoreditch, N.E.
1900 Mar. 10 †1902 May 10	*Hinchsliff, E. R..	Deputy Surveyor, Council Offices, Barry.
1900 Aug. 25 †1902 Mar. 22	*Holloway, W. C.	Chief Engineering Assistant, Council Offices, Kettering.
1902 Feb. 22	Horton, J. W.	Deputy Co. Surveyor, Hertfordshire. 41 Parliament Street, Westminster, S.W.
1902 Feb. 22	Hutton, S.	Chief Assistant, City Engineer's Office, York.
1895 July 27 †1902 Jan. 25	*Jenkins, A. J., A.M.Inst.C.E.	Deputy Borough Engineer, Town Hall, Burton-on-Trent.
‡1897 July 31 †1902 Nov. 8	*Jenkins, R. J.	District Surveyor, Town Hall, Portsmouth.
1900 June 16 †1901 Oct. 19	*Jerram, G., A.M. Inst. C.E.	Chief Engineering Assistant, Town Hall, Walthamstow, N.E.
1897 June 19 †1902 Jan. 25	*Johnston, R. W.	Deputy Borough Engineer, Town Hall, Birkenhead.
1902 May 10	Ker, A. M., A.M. Inst. C.E.	Assistant Borough Engineer, Town Hall, Warrington.
1902 Mar. 22	Lancashire, W. T.	Deputy City Surveyor, Town Hall, Sheffield
1901 Dec. 7	Lashmore, E. W...	District Surveyor, 63 Queen Square, Bristol.
1901 May 11 †1901 Oct. 19	*Lismer, A. B.	Engineering Assistant, Town Hall, Croydon.
1902 Nov. 8	McKenzie, L. S., A.M.Inst.C.E.	District Surveyor, 63 Queen Square, Bristol.
1900 Apr. 21 †1901 Dec. 7	*Miller, G. F.	Chief Assistant, Borough Engineer's Office, Hastings.

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Date of Election and Transfer.		
1898 Dec. 17 T1901 Oct. 19	*Mitchell, G.	Chief Assistant, Borough Water Engineer's Office, Warrington.
G1901 Aug. 24 T1902 Nov. 8	*Neave, J.	Chief Assistant, Engineer's Department, Town Hall, Walthamstow.
1902 Jan. 25	Oakes, H. H...	Assistant Borough Engineer, Town Hall, Bridlington.
1895 June 27 T1902 July 10	*Openshaw, J., A.M.Inst.C.E.	Chief Engineering Assistant, Town Hall, Salford.
1900 June 16 T1902 Feb. 22	*Percival, W.	Assistant Borough Surveyor, Court House, Longton, Staffs.
1895 Jan. 19 T1901 Oct. 19	*Perkins, J.	Engineering Assistant, Council House, Birmingham.
1902 Mar. 22	Phillips, G. A.	Deputy County Surveyor, Glamorgan. Town Hall, Bridgend.
1902 Mar. 22	Ransom, W.	Chief Assistant Surveyor, Worcester. Midhurst, Bath Road, Worcester.
1897 June 19 T1901 Dec. 7	*Redfern, J. L.	Deputy City Engineer, Carlisle.
1901 Aug. 24 T1902 Sep. 6	*Royle, F. M., Assoc. M. Inst. C.E.	Chief Engineering Assistant, Guildhall, Nottingham.
1902 Nov. 8	Rowbottom, J.	Chief Assistant, Borough Surveyor's Office, Ashton-under-Lyne.
1894 Oct. 20 T1902 May 10	*Savage E. B., A.M.Inst.C.E.	Engineering Assistant, Council House, Birmingham.
1902 Nov. 8	Shackleton, W.	Chief Assistant, Borough Engineer's Office, Hanley.
1899 Dec. 16 T1901 Oct. 19	*Slater, F. J.	Assistant Surveyor, Town Hall, Camberwell, S.E.
1898 Dec. 17 T1901 Oct. 19	*Smith, J. W.	Borough Engineer, Town Hall, Barrow-in-Furness.
1899 Dec. 16 T1901 Oct. 19	*Spreckley, J. A., A. M. Inst. C.E.	Deputy City Surveyor, Hereford.
1901 Dec. 7	Spurr, F. W.	Chief Assistant, City Engineer's Office, York.
1895 Jan. 19 T1901 Oct. 19	*Steele, W. J., A.M. Inst. C.E.	Deputy City Engineer, Bristol.
1898 Dec. 17 T1902 Jan. 25	*Taylor, J.	Tramways Engineer, Town Hall, Bradford.
1899 June 10 T1902 Mar. 22	*Weir, J. S.	Chief Assistant, Borough Surveyor's Office, Halifax.
1902 Mar. 22	Williams, H. B.	Chief Assistant, Borough Engineer's Office, Workington.
1902 July 10	Williams, J.	Assistant Borough Surveyor, Town Hall, Hampstead, N.W.
1898 June 30 T1901 Dec. 7	*Willis, E., Assoc. M. Inst. C.E.	Chief Engineering Assistant, Council Offices, Willesden, N.W.
1898 June 30 T1901 Dec. 7	*Wilson, F.	District Surveyor, 63 Queen Square, Bristol.
1891 Aug. 1 T1901 Oct. 19	*Yarwood, H.	Assistant Borough Surveyor, Town Hall, Rochdale.
1901 June 8 T1902 Feb. 22	*Yelland, T.	Deputy Borough Engineer, Town Hall, Leigh, Lancs.

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GRADUATES.

All Graduates hold the Certificate of the Association.

Date of Election.		
1893 Oct. 2	BALL, J. B., A.M. Inst. C.E.	Engineer's Office, L.D. & E.C. Railway, Chesterfield.
1901 Aug. 24	BARKER, H. W.	Surveyor to the Urban District Council, Walmer.
1890 Mar. 29	BAYLEY, G. H., A.M.Inst.C.E.	17 Cooper Street, Manchester.
1901 June 8	BEACHAM, W. E.	Town Hall, Rochdale.
1897 July 31	BEARD, E. T., A.M. Inst. C.E.	4 The Crescent, Scarborough.
1898 Dec. 17	BELL, B.	City Surveyor's Office, Carlisle.
1902 Mar. 22	BERRINGTON, G. E. W... ..	28 Victoria Street, Westminster, S.W.
1900 June 16	BLAKEWAY-PHILLIPS, R. ..	City Engineer's Office, Westminster, S.W.
1901 Aug. 24	BLANCHARD, R.	Town Hall, Leicester.
1889 June 8	BLIZARD, J. H., A.M.Inst.C.E.	Lansdowne House, Southampton.
1899 June 10	BRADSHAW, A. S.	Borough Engineer's Office, Bedford.
1892 Oct. 15	BRADSHAW, J. B., A.M. Inst. C.E.	56 Rothwell Road, Gosforth, Newcastle.
1898 June 30	BRISCOE, J. T.	"Laurel Dene," Southbury Road, Enfield, N.
1896 June 25	BRUCE, W...	Borough Engineer's Office, Edinburgh.
1889 July 4	BRYANS, J. G.	Assistant Engineer, Buenos Ayres and Pacific Railway, Junin, Argentine.
1899 June 29	BURGESS, R. W.	Town Hall, Stratford, E.
1902 July 10	BUTTON, F. E.	Borough Surveyor's Office, Darwen.
1902 Feb. 22	CAMM, E.	Town Hall, Leicester.
1897 June 19	CARTLEDGE, J. R.	Assistant Surveyor, District Council Offices, Barnes, S.W.
1890 Sept. 13	CATCHPOLE, H.	27 Avenue Villas, Avenue Road, Finchley, N.
1902 June 7	CHAMBERS, H. A.	Borough Engineer's Office, West Hartlepool.
1894 Oct. 20	CHASEMORE, A. E.	98 High Street, Putney, S.W.
1894 July 7	CLAYPOOLE, A. H., A. M. Inst. C.E.	City Engineer's Office, Bristol.
1894 July 7	CLEGG, H.	Borough Surveyor's Office, Oldham.
1897 June 19	CRESWELL, W. T.	R. E. Office, Hong Kong.
1892 July 11	CROSS, F. W., A.M. Inst. C.E.	45 Bradford Street, Walsall.
1900 June 19	CRUMP, E. H...	Council Offices, Nuneaton.
1898 June 30	CUDBIRD, T. O.	City Engineer's Office, Guildhall, Norwich.
1901 June 8	DAVIDGE, W. R.	L.C.C. Offices, 19 Charing Cross Road, W.C.
1902 July 10	DAWKINS, F.	Borough Surveyor's Office, Bournemouth.
1902 July 10	DEELEY, G. P.	Monshall, Amblecote, Brierley Hill, Staffs.
1898 June 30	DENT, J. P.	1 Woodside Terrace, Nelson, Lancashire.

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Date of Election.		
1899 June 29	Dyer, R. H.	Borough Engineer's Office, Southampton.
1898 Dec. 17	Essex, E. H.	Town Hall, Leyton, N.E.
1886 Sept. 11	Fenton, W. C.	14 St. James' Row, Sheffield.
1891 June 25	Finch, A. R., A.M. Inst. C.E.	Town Hall, Kensington, W.
1898 June 30	Finch, E. E.	Town Hall, Bermondsey, S.E.
1900 June 16	Fisher, R.	37 Inman Road, Harlesden, N.W.
1899 Oct. 21	Foster, H. H.	Borough Engineer's Office, West Hartlepool.
1896 Jan. 18	Fox, Senior L.	Town Hall, Newport.
1899 June 10	Gibson, W. S.	"D'Arcyville," Victoria Road, Hendon.
1888 July 12	Glass, S. N., A.M. Inst. C.E.	16 Ravenscroft Road, Chiswick.
1898 Jan. 15	Godfrey, C.H., A.M.Inst.C.E.	Municipal Offices, Shanghai.
1898 Jan. 15	Grimley, F. C.	The Depôt, Harwich.
1901 June 27	Harlow, W. W. R.	Council Offices, High Street, Grays.
1901 June 8	Harris, K. J. S.	St. George's Hall, Mount Street, London, W.
1900 May 19	Harrison, J. W.	106 Raffles Road, Tranmere, Birkenhead.
1899 Jan. 12	Haywood, S. S.	Borough Engineer, Brighouse.
1893 Jan. 14	Hellawell, O.	Town Hall, Withington, Manchester.
1896 June 25	Hills, O. C.	147 Bow Road, E.
1900 June 16	Hobson, E.	6 Keyworth Road, Hillsborough, Sheffield.
1888 July 12	Houghton, J.	King's Heath, Birmingham.
1901 Aug. 24	Hull, G. E.	St. Mary's Hall, Coventry.
1899 June 10	Hutchings, W. A...	Town Hall, Islington, N.
1898 Jan. 15	Jeffes, R. H.	Surveyor to the Urban District Council, Cheshunt.
1901 May 11	Johnston, C.	163 Grosvenor Road, Westminster, S.W.
1901 June 8	Jones, H. O.	Borough Engineer's Office, Folkestone.
1895 Oct. 19	Julian, J.	Borough Surveyor's Office, Cambridge.
1896 June 25	Kieser, W. H. G.	City Engineer's Office, Bristol.
1893 June 24	Killick, W. H.	Borough Surveyor's Office, Southampton.
1896 June 25	Kirk, J. W.	Town Hall, Westminster, S.W.
1900 Dec. 15	MacDonald, K. G.	13 Charles Street, St. James's, S.W.
1894 Jan. 13	Martin, E. B., A.M.Inst.C.E.	City Engineer's Office, Leeds.
1900 June 16	Mattinson, H.	55 Piccadilly, Manchester.
1898 Dec. 17	May, C. G.	P.W.D., Malacca, Straits Settlements.
1901 Oct. 19	Milnes, B.	Town Hall, Birkenhead.
1899 June 10	Moss, P. A.	121 Highbury Hill, Highbury, N.
1902 Jan. 25	Moss, W.	36, Hall Lane, Failsworth, Manchester.
1902 July 10	Nathanielsz, A. H.	Water Engineer's Office, 45 John Street, Glasgow.
1896 June 25	Nightingale, C. F.	6 Westbourne Road, Walsall.
1901 Aug. 24	Oxberry, F. W.	32 East Mount Road, York.
1899 Oct. 21	Palmer, G. F.	21 Lester Road, Chatham.
1901 Feb. 6	Palmer, W. L. F...	City Engineer's Office, Bristol.
1902 Mar. 22	Parr, J. E.	Council House, Handsworth, Staffs.

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Date of Election.		
1896 Feb. 22	PERKINS, T. L., A.M. Inst.C.E.	4 Linzee Road, Hornsey, N.
1902 July 10	PHILLIPS, R.	36 Tyssen Street, Dalston, N.
1901 Aug. 24	PICKIN, W. H.	Sewerage Works, Rickmansworth.
1899 Oct. 21	PLANT, W.	Borough Engineer's Office, Leicester.
1888 Sept. 15	PRITCHARD, T., A.M.Inst.C.E.	264 Gresham House, Old Broad Street, E.C.
1898 June 30	QUICK, A. H.	15 Fernholme Road, Newlands, S.E.
1900 Dec. 15	RAWSTRON, C. O.	29B High Street, Rotherham.
1901 June 8	READ, F...	Town Hall, Leyton, N.E.
1902 Nov. 8	REDFORD, W. T.	Town Hall, Eccles, Lancs.
1899 Mar. 25	RICHARDS, E. P.	Borough Engineer's Office, Southend-on-Sea.
1901 Aug. 24	RILEY, J.	Avondale House, Orchard Road, Erdington, Birmingham.
1899 June 29	ROSE, J. G.	Great Knollys Street, Reading.
1900 Feb. 10	ROSS, D.	Brede, Sussex.
1901 Feb. 16	ROTHERA, A.	Borough Engineer's Office, Salford.
1900 June 16	ROUSELL, A. J.	Borough Engineer's Office, Worthing, Sussex.
1902 July 10	SHEPHERD, G. G.	Town Hall, Ilford.
1899 June 29	SIMMS, F.	Town Hall, Sheffield.
1898 Jan. 15	SMITH, G. H.	1 Worcester Road, Wimbledon, S.W.
1898 June 30	SPINK, J.	City Surveyor's Office, Manchester.
1899 June 29	STANTON, F. W. S.	c/o J. Mansergh, Esq., 5 Victoria Street, S.W.
1898 June 30	SUTTON, W. F.	Water Department, Broad Street, Birmingham.
1902 Feb. 22	TAIT, W. I.	Council Offices, Nuneaton.
1900 Dec. 15	TAYLOR, H. T.	24 Fountain Street, Tranmere, Birkenhead.
1902 July 10	TAYLOR, S.	Town Hall, Manchester.
1900 Dec. 15	TAYLOR, P.	Council Offices, Ilford, Essex.
1895 Jan. 19	THACKERAY, F.	43 Richmond Terrace, Darwen.
1899 June 10	THACKERAY, J. R.	Borough Engineer's Office, Eastbourne.
1902 Jan. 25	THOMAS, W. G.	Daylesford, Mountain Ash.
1898 June 30	TIFFIN, T. E.	York Road South, West Hartlepool.
1900 June 16	TREMELLING, H.	Borough Engineer's Office, Newport, Mon.
1902 July 10	TOMLINSON, J. W...	St. Mary's Hall, Coventry.
1900 Oct. 13	TOMPKINS, H...	6 Ethel Street, Wells, Somerset.
1900 June 16	TOWNER, H. V.	Adelphi Hotel, Singapore.
1899 Oct. 21	TWAITS, J.	Town Hall, Mile End, E.
1893 June 24	VIDEAN, H. N.	Bournemouth Road, Folkestone.
1902 Nov. 8	WALKER, A. H.	128 Prince of Wales Road, London, N.W.
1900 Dec. 15	WALKER, H.	Whyteleafe, Cecil Road, Wealdstone.
1888 Jan. 14	WARD, F. D., A. M. Inst. C.E.	38 High Street, Welshpool.
1900 May 19	WARLOW, W. R.	Nolton House, Windmill Road, Brentford.
1898 Jan. 15	WARREN, A. R.	Surveyor to the Urban District Council, Milton-next-Sittingbourne.

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Date of Election.		
1897 June 19	WEBB, F.	Town Hall, Chelsea.
1898 Jan. 15	WELLS, F. B.	c/o The Great Southern Railway Co., Buenos Aires, South America.
1902 Sept. 6	WEST, A. S.	Borough Engineer's Office, Harrogate.
1902 Jan. 25	WHITE, C. D.	Council Offices, Hanwell.
1901 June 8	WHITEFORD, E. H., A.M. Inst. C.E.	Engineer's Office, Derwent Valley Water Board, Bamford, near Sheffield.
1902 July 10	WHITAKER, G. H.	74 Bridge Street, Birkenhead.
1898 Dec. 17	WHITWORTH, W.	Cradley Heath, Staffs.
1902 Nov. 8	WIBBERLEY, J.	Assistant Borough Surveyor, Municipal Offices, Guildford,
1901 June 27	WILLETT, A. J.	24A Tremaine Road, Anerley, S.E.
1902 July 10	WILKINSON, F.	Municipal Offices, Rawtenstall.
1901 Aug. 24	WILKINSON, H. F.	Fulford House, The Crescent, South Tottenham, N.
1895 June 27	WILLIAMS, D. S.	Hopes Green Road, South Benfleet, Essex.
1901 Dec. 7	WILLIAMS, J. H.	Town Hall, Burnley.
1902 Sept. 6	WILLIAMS, W. W.	14 Countess Street, Stockport.
1900 Dec. 15	WILLS, A. J.	Harrisburg, Pennsylvania, U.S.A.
1901 Aug. 19	WILSON, H. B.	Town Hall, Wood Green, N.
1900 July 19	WRACK, W. P.	117 High Street, Poplar, E.

PARLIAMENTARY AND GENERAL PURPOSES COMMITTEE.

J. P. BARBER (Islington), *Chairman*.

W. N. BLAIR (St. Pancras).
J. W. COCKRILL (Great Yarmouth).
A. D. GREATOREX (West Bromwich).
W. HARPUR (Cardiff).
CHAS. JONES (Ealing).
E. G. MAWBEY (Leicester).
J. PRICE (Birmingham).
O. C. ROBSON (Willesden).
H. T. WAKELAM (Westminster).
W. WEAVER (Kensington).

T. H. YABBICOM (Bristol).

FINANCE COMMITTEE.

W. WEAVER (Kensington), *Chairman*.

J. P. BARBER (Islington).
J. A. BRODIE (Liverpool).
A. E. COLLINS (Norwich).
W. HARPUR (Cardiff).
C. JONES (Ealing).
J. S. PICKERING (Nuneaton).
J. PRICE (Birmingham).
C. F. WIKE (Sheffield).

T. H. YABBICOM (Bristol).

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THE

INCORPORATED ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS.

TWENTY-NINTH ANNUAL MEETING.

BRISTOL, *July* 10, 11 *and* 12, 1902.

THE Members assembled in the Council House, Bristol, the use of which had been kindly granted by the Lord Mayor and Corporation.

The Lord Mayor (Mr. Alderman Chas. E. L. Gardner) offered the Association a very hearty welcome to Bristol.

The President, Mr. E. G. Mawbey, on behalf of the Association, returned thanks to his Lordship for the kind welcome offered them.

The Members then adjourned to the Lecture Theatre of the Corporation Museum and Library, the use of which had been kindly granted.

The President reported that at a Special Council Meeting held at the offices of the Association on Saturday, June 28, 1902, the following message of sympathy in the illness of the King was sent to Her Majesty the Queen:—

"At a meeting of the Council of the Incorporated Association of Municipal and County Engineers, held to-day, the following resolution was directed to be forwarded to your Majesty: 'The Council most respectfully desire to express their heartfelt sympathy with your Majesty in the sad trouble through which you are now passing, and earnestly pray that the means used may be blessed to the King's speedy recovery."

The Secretary received the following telegram in reply:—

"The Queen thanks you for your kind sympathy. The King is making satisfactory progress."

On the recovery of the King the following telegram was despatched:—

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"The President, on behalf of 1000 Members and Graduates of the Incorporated Association of Municipal and County Engineers, begs most respectfully to express the deepest heartfelt joy and gratitude on hearing that his gracious Majesty the King is out of danger."

A reply was received as follows:—

"The President of the Incorporated Association of Municipal and County Engineers, Town Hall, Leicester.—I am commanded by the King to thank you for your kind telegram of congratulation. His Majesty continues to make very satisfactory progress.—KNOLLYS."

The Secretary then read the Minutes of the last Annual General Meeting, which were confirmed and signed.

The Secretary read the Council's Annual Report.

ANNUAL REPORT.

In presenting the Report of the proceedings of the past year the Council have much satisfaction in stating that the progress of the Association is well maintained.

DISTRICT MEETINGS.

Six District Meetings have been held: At Swadlincote, July 20, 1901; at Southend-on-Sea, September 28; at Nuneaton, October 12; at Birmingham, April 5, 1902; at Newbury, May 31; and at Wolverhampton, June 14.

THE ROLL OF THE ASSOCIATION.

During the financial year ended April 30 last, 78 new Members, consisting of 26 Ordinary Members, 18 Associates and 34 Graduates, have joined the Association; 6 Members have resigned, 14 names have been written off, and the Council record with regret the deaths of Messrs. P. H. Brown, J. Cooper, G. H. Lilley, T. T. Marks, and C. L. H. Wilson.

The number on the Roll of the Association at the close of the year was 9 Honorary Members, 823 Ordinary Members, 58 Associates and 129 Graduates, making a total of 1019, being an addition of 5·5 per cent. on the numbers of the preceding year.

The Council have transferred Messrs. A. Burton, F. T. Grant,

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C. Hall, J. S. Hendry, F. Hutton, M. Lea, C. W. Marks, T. E. Swales, L. J. Veit and A. S. Wooton from the class of Graduates to that of Members, these gentlemen having been appointed to positions qualifying for this class under the Articles of Association.

Mr. E. B. Newton, being duly qualified, has been transferred from the class of Associates to that of Members.

The Council have transferred 40 Graduates to the class of Associates, these gentlemen holding the positions and qualifications required by the Articles.

The Finances.

The Audited Balance-Sheet and Statement of Accounts which accompany this Report show a Balance in hand on April 30 last of 477*l.* 1*s.* 5*d.* As will be seen by the Statement of Liabilities, this is exceeded by the amounts owing by the Association on that date. This fact is due to abnormal expenditure in connection with the publication of the 'Proceedings of Section 7 of the Glasgow International Engineering Congress,' coupled with the investment of 250*l.* in each of the two last succeeding years.

The Council are therefore enabled to report with much gratification that the steady improvement heretofore reported is again shown in a marked degree.

The Examinations.

Since the last Report three examinations have been held, one at Manchester on October 18 and 19, 1901, when 31 candidates presented themselves for examination. Of these 11 satisfied the examiners and were granted their certificates. The examiners were Messrs. Collins, Eayrs, Fowler and Lobley.

The second examination was held in London on April 11 and 12, 1902, when 32 candidates presented themselves, of whom 15 satisfied the examiners and were granted their certificates. The examiners were Messrs. Barber, Jones, Lowe and Price.

The third examination was also held in London on April 18 and 19, 1902, when 28 candidates presented themselves, of whom 16 satisfied the examiners and were granted their certificates. The examiners were Messrs. Collins, Fowler, Lemon and Lobley.

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The New Council.

The ballot lists having been duly issued, the scrutineers reported the result of the voting as follows:—

President—Mr. T. H. Yabbicom.

Vice-Presidents—Messrs. J. Patten Barber, A. T. Davis and W. Weaver.

Ordinary Members of Council—Messrs. W. N. Blair, J. W. Bradley, J. A. Brodie, E. Buckham, A. E. Collins, A. Creer, A. D. Greatorex, E. P. Hooley, E. J. Lovegrove, A. B. McDonald, J. Paton, S. S. Platt, J. Price, H. T. Wakelam and C. F. Wike.

Honorary Treasurer—Mr. Lewis Angell.

Honorary Secretary—Mr. Charles Jones.

Elective Past-Presidents—In accordance with the Articles of Association the following gentlemen, Past-Presidents, were elected by the Council: Mr. O. C. Robson for the three ensuing years, Mr. J. Lobley for the two ensuing years, and Mr. J. T. Eayrs for the ensuing year.

Premiums.

The Council have awarded the Association's first premium of 10*l.* in books to Mr. W. Howard-Smith for his paper on "Permanent Way for Electric Tramways," read at the Annual Meeting held at Leicester in June 1901, and the second premium of 5*l.* to Mr. J. Kemp for his paper on "Sewerage and Sewage Disposal Works at Hampton-on-Thames," read at the District Meeting held at East Molesey and Hampton-on-Thames in October 1900.

Superannuation.

In connection with the passage of the Local Authorities Officers' Adoptive Superannuation Bill, 1902, through Parliament, a deputation, representative of the various societies interested, waited upon the President of the Local Government Board in April last.

The Right Honourable the President promised his assistance in getting the Bill through the Committee stage, and it is understood that the Government will support it in the House. A circular setting forth the present position and prospects of the Bill was issued to the Members of the Association, urging communication with local Members of Parliament. It is con-

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fidently hoped that if the Members of the Association unite in their efforts and obtain influential support, the measure will before long be an accomplished fact, thus placing the surveyor in a position to obtain the same benefits as are available to poor law officers under the Poor Law Officers Bill.

Glasgow International Engineering Congress.

As previously stated, the Association were entrusted with the charge of Section VII. (Municipal) of the International Engineering Congress held at Glasgow in September last. A number of papers were read and discussed at the meetings before large and appreciative audiences. Several works of great interest were visited and inspected. The whole of the proceedings of the section are published in an illustrated volume, which has been issued to the Members of the Association and to others interested in the work of the section.

Alterations in the Articles and Bye-Laws.

Several alterations in the Articles of Association and in the Bye-laws were passed at a Special General Meeting held at Leicester on June 27 of last year. These were, in accordance with the provisions of the Companies Act, confirmed by special meeting held in London on July 24, 1901. The Articles and Bye-laws as amended, are printed *in extenso* in Vol. XXVII. of the 'Proceedings.'

Payment of Expenses of Members Attending Meetings.

This matter has again occupied the attention of the Council. A letter has recently been addressed to the Local Government Board praying for an amendment of clause 2, chapter 22, Public Health and Local Government Conferences Act, 1885—48 and 49 Vict.—to provide for expenses incurred in relation to conferences of local authorities: so as to make it applicable not only to the clerk to the authority, but to the engineer or other officer duly appointed. Your Council urged that it is manifestly unfair that Municipal Engineers should be required to provide, out of their own purse, expenditure having for its object the acquirement of knowledge invaluable to the district represented.

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The Case of Dismissal from Office.

One of your Members, late the City Engineer of a Colonial town, in a communication addressed to your Council, set forth his dismissal from office without just cause, and appealed to the Association for assistance in obtaining redress. The matter having been considered by your Council, it was resolved to submit the papers received to his Majesty's Secretary of State for the Colonies, which was accordingly done. Your Council feel sure that if injustice has been done, its being brought to the notice of the Colonial Secretary will ensure full redress.

The Engineering Standards Committee.

This committee, formed under the auspices of the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Naval Architects, and the Iron and Steel Institute, have asked your Council to appoint two representatives on the sub-committee specially dealing with the standardisation of tramway rails.

Messrs. W. Harpur, of Cardiff, Past-President, and C. F. Wike, of Sheffield, Member of Council, were requested by the Council to serve on such sub-committee, and these gentlemen have consented so to do.

List of Members.

In accordance with a wish expressed at the last Annual Meeting, the dates of election and of transfer have been printed against the name of each Member, Associate, and Graduate in the List of Members.

Chas. Jones, *Hon. Sec.*
Thomas Cole, *Secretary.*

The Secretary then read communications from:—The Local Government Board: to the effect that the representations of the Association would be noted for consideration in connection with any proposed legislation upon the subject; and from H.M. Secretary of State for the Colonies stating that the papers would receive consideration, and that Lord Milner was being asked for a report on the matter.

On the motion of the President, seconded by Mr. A. T. Davis, the Report was received and adopted.

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It was moved, seconded, and carried, that the various District Secretaries continue in office till the next meeting in their respective districts.

Mr. Stallard and Mr. MacBrair were appointed Auditors for the ensuing year.

Messrs. F. J. Harris, H. Shaw and F. S. Yates were appointed Scrutineers for the ensuing year.

Mr. Mawbey, the retiring President, then introduced his successor, Mr. T. H. Yabbicom, and vacated the chair in his favour.

A vote of thanks to the retiring President was proposed by Mr. J. Patten Barber, seconded by Mr. A. D. Greatorex, and accorded with acclamation.

Mr. Mawbey having acknowledged the vote,

Mr. Yabbicom then read his Inaugural Address,* a hearty vote of thanks for which was proposed by Mr. James Lemon, seconded by Mr. J. T. Eayrs, and carried.

The following papers were read and discussed :—

"Twenty-Five Years of Municipal Progress in Bristol," by T. H. Yabbicom. "Wear and Maintenance of Tramways," by C. F. Wike. "Underground Conveniences," by J. R. Dixon. "The Construction of the Continuous Sewage Filter," by F. W. Stoddart. "Motor Vehicles for Borough and County Work," by E. Manville. "Analysis of Macadam Road Construction," by C. H. W. Biggs. "Flood Prevention Works in Bristol," by W. J. Steele. "Extensions at Infectious Diseases Hospital at Ham Green, Bristol," by H. W. Harding. "Bristol Tramways Electrical Installation," by J. C. Robinson. "Notes of Electrical Works in Bristol," by H. F. Proctor. "Sea Mills Sewage Disposal Works," by A. P. I. Cotterell. "Yeo Reservoir and Pumping Station at Blagdon," by H. W. Pearson.

Votes of thanks were accorded to the Authors of the papers, to the Lord Mayor and Corporation, for the use of the rooms in the Council Chamber, and for the use of Lecture Theatre and rooms in the Corporation Museum, and to the President, Mr. T. H. Yabbicom.

* This Address and the Papers read at the Meeting will be found at the end of this Volume.

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Dr. STATEMENT OF RECEIPTS AND EXPENDITU

RECEIPTS.	£	s.	
To Balance, May 1, 1901	297	9	
„ Entrance Fees of Members and Associates	44	2	
„ Subscriptions	740	5	
„ New Graduates	14	3	
„ Subscriptions in advance	16	10	
„ Arrears	124	9	
„ Sale of 'Proceedings'	20	9	
„ Examination Fees	334	8	
„ Interest on Investments	37	12	
„ Sale of Glasgow Congress Volume	23	6	1
„ Balance of Petty cash, May 1, 1901	3	17	
„ Balance of Petty cash due to Secretary, April 30, 1902	2	14	1
£	1659	9	

STATEMENT OF ASSE

LIABILITIES.	£	s.	d.	£	s.
To Estimated Liability on Vol. XXVIII.		..		40	0
„ Examination Expenses		..		107	0
„ Sundry Printing, Stationery, &c.		..		10	18
„ Reporting		..		8	8
„ Secretary, Petty cash		..		2	14
„ „ for Assistant		..		5	0
„ Sundry Creditors		..		10	0
„ Messrs. Clowes—					
For Printing Vol. XXVII.	288	7	6		
„ „ Glasgow Congress Vol.	95	0	3		
„ „ Alteration Articles	16	3	3		
„ „ Sundries	56	2	9		
For postages of Volumes and Circulars	63	15	2		
	519	8	11		
Less Discount	22	15	9		
				496	13
„ Balance		..		1379	16
£				2060	10

Examined and found correct.

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FOR THE YEAR ENDING APRIL 30, 1902. Cr.

EXPENDITURE.	£ s. d.	£ s. d.
By Reports of Meetings	..	58 16 0
„ Examiners' Fees and Expenses	..	129 15 3
„ Auditors' Expenses	..	2 2 0
„ Scrutineers' Expenses	..	8 3 0
„ Meetings, Expenses	..	44 9 3
„ Printing and Stationery	..	46 11 7
„ Messrs. Sprague, Illustrations	..	158 2 6
„ Rent of Telephone	..	17 0 0
„ Secretary, Salary and Rent	..	300 0 0
„ Allowance for Assistant	..	57 0 0
„ Travelling Expenses	..	49 16 1
„ Bankers' Charges	..	0 16 0
„ Purchase of 2½ % India Stock	..	250 0 0
„ Sundries, Office Furniture	..	8 3 6
„ Petty Cash—		
Postages	34 17 0	
General	16 15 7	
		51 12 7
„ Balance	..	477 1 5
	£	1659 9 2

AND LIABILITIES.

ASSETS.	£ s. d.	£ s. d.
By Balance at Bank, May 1, 1902	..	477 1 5
„ £490 Southampton Corporation Stock at 96 ..	..	470 8 0
„ £553 12s. 9d. India 2½ % Stock at 89	..	492 14 0
„ £261 14s. 7d. London County Council 2½ % Consols at 89	..	232 18 0
„ £200 Metropolitan 2½ % Consolidated Stock, at 89	..	180 0 0
„ Subscriptions in Arrear	201 6 0	
Less 50 per cent. bad	100 13 0	
		100 13 0
„ 'Proceedings' in Stock	295 16 0	
Less 75 per cent.	222 0 0	
		73 16 0
„ Office Furniture	..	33 0 0
	£	2060 10 5

...th day of June, 1902.

S. STALLARD, *Auditor.*

LEWIS ANGELL, *Treasurer.*
CHAS. JONES, *Hon. Secretary.*
THOMAS COLE, *Secretary.*

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DISTRICT MEETING AT SWADLINCOTE.

July 20, 1901.

Held at the Council Chamber, Swadlincote.

E. GEORGE MAWBEY, M. INST. C.E., PRESIDENT, *in the Chair.*

THE Chairman of the Council (Mr. J. H. Stevens) received the Members, offering them a hearty welcome to the town.

The President, on behalf of the Association, thanked the Chairman and the Members of the Swadlincote Urban District Council, and the Chairman and Members of the Swadlincote and Ashby-de-la-Zouche Joint Water Board for their great kindness in granting the use of rooms and permission to see the works.

In the absence of the Honorary District Secretary (Mr. J. S. Pickering), Mr. Greatorex acted as Honorary Secretary.

Mr. Pickering was unanimously re-elected Honorary District Secretary for the Midland District.

A vote of sympathy was passed to Mr. Pickering and Mr. Yates, and the hope was cordially expressed that they might speedily recover from the effects of the unfortunate accident by which they were injured at the Leicester meeting. Letters were read from both gentlemen, reporting satisfactory progress towards recovery.

The following paper was then read and discussed:—

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PUBLIC WORKS OF SWADLINCOTE.

By THOMAS KIDD, Assoc. M. Inst. C.E., Town Surveyor and Waterworks Engineer.

In compliance with a request of the Honorary Secretary of the Midland District, the Author has much pleasure in giving as concisely as possible an account and description of Swadlincote, including a few public works carried out by the Urban District Council and the Joint Water Authority.

General.

The area of Swadlincote district is 3415 acres, with 11 miles of streets, 7½ miles of main roads, exclusive of the private streets and roads now being made—or about to be made up. The population according to the census returns of 1901 is 18,014. The following tabulated statement will show at a glance the growth of the population since 1851, and number of houses erected since 1881 :—

Population and Number of Houses in the Year.

—	1851.	1861.	1871.	1881.	1891.	1901.
Population ..	4094	5597	7846	11,893	13,889	18,014
Houses	..	..	..	2,289	2,633	3,459

Swadlincote is situate in the southern portion of Derbyshire, and bounded on two sides by Leicestershire and Staffordshire.

Industry.

Some fifty years ago Swadlincote was merely a small village, the inhabitants finding employment in the small coalpits, which at that time depended on local sale, and the earthenware

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works, where the cane-coloured and Rockingham ware was manufactured, and other works that were just coming into existence.

The excellent quality of the fire and other clays had already been discovered, but engaged little attention on account of the difficulty experienced in conveyance of the goods to the various markets.

Postal facilities, so necessary now to the quick transaction of business, were conspicuous by their absence, the nearest telegraph station being Burton-on-Trent, 5½ miles distant.

A remarkable feature was the large tract of land in the centre of the district, known as Gresley Common, with adjoining lands, which were partly covered with thicket, the former being moorland.

Very few were aware of the vast mineral wealth of stoneware, fire-clay and coal underlying this apparently waste land; since that time, the seams have been proved to exist practically throughout the district.

Just about this time, the sanitary question was taking hold of this country, and for sewerage and drainage works, the superiority of the new salt-glazed stoneware pipe over the rough agricultural tubes was apparent to all. Upon trials being made, the clays of this district were found second to none in producing stoneware pipes and other appliances—the action of the salt forming an excellent glaze with a thoroughly vitrified surface of ample strength and durability. A new industry was thus born to the district, and the Midland Railway Company were not slow to construct a branch line to Swadlincote, thus in a great measure overcoming its isolated position for transit.

The aspect of things now very quickly changed. Works began to spring up, and smoking chimneys and kilns to dot the landscape, and in a very short time the manufacture of stoneware and earthenware goods was looked upon as the staple trade of the district.

Coal being such an important factor in the manufacture of these goods, colliery enterprise was greatly benefited. The result was a large investment of capital in opening out and sinking new shafts.

To-day the Swadlincote district is looked upon as the largest

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sanitary pipe-producing one in the whole world—and this morning the members will have the pleasure of visiting one or two of these typical works, through the kindness of Messrs. James Woodward, Limited, and Messrs. Thomas Wragg and Sons, Limited, who have kindly consented to keep open their works, so that the members present may have an opportunity of witnessing the actual manufacture of the articles and other appliances now so common to municipal and sanitary engineers.

There are also splendid seams of fire-clay from which the large Sheffield steel and iron firms are supplied with fire-bricks. The finer kinds of crucible clay are mined similarly to coal, and are in great request by steel melters, both in England and abroad, and have even been purchased by the progressive Japanese.

A later industry is the manufacture of glazed bricks, at present made extensively by one firm, whose works, modern machinery and plant, have been pronounced by both English and foreign experts to be quite a model.

Time will not permit the Author to dwell upon the manufacture of mosaic and other tiles, earthenware, Bretley ware, etc. Suffice it to say that when the earthenware industry sprang up here, there were only two other makers, the whole employing probably not more than twenty or thirty men, whilst to-day it has grown to such an extent, that no less than 4000 highly skilled artisans find employment.

The making of these goods up to the present has been almost entirely by hand, no machinery of much worth having been found possible to do the work until 1901 when a neat little machine, designed in the district, was put on the market for the manufacture of these goods, which will doubtless lead to their more extensive use in our homes.

Export Trade.

Swadlincote has a large export trade with France, Germany, Belgium and other Continental countries, also with India, Africa, South America, Australia and elsewhere.

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Health of District.

The district, considering the nature of the works and employment of the masses, may be looked upon as being very healthy—the death and birth rates being tabulated for four years as below:—

Year.	Death rate per 1000.	Birth rate per 1000.	Zymotic rate per 1000.
1894	17·57	41·97	2·81
1898	18·12	41·37	3·41
1899	16·58	40·82	3·10
1900	14·46	39·86	2·73

Bye-Laws and Regulations.

The bye-laws and regulations in operation are dated 1871, and if properly administered and carried out are suitable for a district like this—without the usual tendency to cripple the building trades.

The annotated bye-laws as approved by the Local Government Board are in the Author's opinion an excellent code, yet like many other good works are not suitable for all districts alike.

Sewerage and Sewage Disposal.

The main system was designed and carried out by the late Mr. A. Marshall, prior to the Author's appointment, at a cost, including the purchase of land, of 30,770*l*. The main outfall sewer is 21 inches diameter, made of best stoneware with deep sockets, and laid at a gradient of 1 in 800.

The sewerage extensions and storm-water sewers in various parts of the district have been designed and carried out by the Author. Flushing chambers are about to be constructed in various parts of the district, the capacity ranging from 200 to 400 gallons each. The ventilation of the sewers by open gratings at the street level has been in many instances a source of constant complaint, owing to the stench. A system of ventilation by means of cast-iron shafts with air inlets has therefore been adopted, and, where carried out, has given every satisfaction.

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Sewage Disposal.

The sewage is delivered by gravitation on to the sewage farm 64 acres in extent, laid out in beds, with distributing carriers and chambers, and is under-drained 5 to 6 feet deep, by 9-inch pipes laid herring-bone fashion, 66 feet apart; the crops grown thereon being rye-grass, osiers, mangolds, turnips, carrots, cabbages, celery, potatoes, etc., part of the produce being consumed on the farm by the cattle, the remainder disposed of as far as possible in the district. The cost of working the farm for the year ending March 1900 (including rates and taxes) was 578*l.* 7*s.* 10*d.*, and the receipts for produce sold, etc., 557*l.* 9*s.* 2*d.*, leaving a balance of 20*l.* 18*s.* 8*d.* to be provided by the rates.

Night Scavenging.

The night-soil scavenging and collection of house refuse has been carried out by the Council's own workmen for several years—the cost to the rates for year ending March 31, 1900, being 791*l.* 19*s.* 4*d.* The Council have decided to erect a refuse-destructor; plans are now being prepared by the Author. The heat probably will be utilised for absorbing the moisture out of the material used for making tar macadam and asphalt.

Lighting.

Part of the public streets are lighted by means of 400 gas lamps, each consuming 5 cubic feet per hour, the remainder being lighted by electricity, purchased from the Right Hon. the Earl of Carnarvon. Plans prepared by the Author have been approved for extending the electric lighting, and will shortly be carried out.

Water.

The water supply is derived from the Milton watershed (referred to later), and, after being pumped into Woodville reservoir, gravitates into this district—the consumption for the year ending March 31, 1900, being 67,612,000 gallons, equal to an average of about 10 gallons per head per day. Consumers may be supplied and charged on rateable value, or by meter at a fixed minimum charge. At present we have over 500

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meters of various sizes in use in the district. Since 1898 the water mains have been extended in order to cope with the needs of the district.

Gas-Works.

The gas-works were purchased by the Urban District Council in 1898, the cost being as follows:—

	£	s.	d.	£	s.	d.
Award of Sir George B. Bruce..	34,219	0	0			
Miscellaneous expenditure.. ..	3,405	2	6			
				37,624	2	6
Cost of Act of Parliament				1,370	0	0
The works have been enlarged since taking them over by erecting new scrubber, washer, condensers and purifiers, capable of dealing with an output of 250,000 cubic feet per day, and other distributing plant and appliances at a cost of ..				8,839	17	5
				£47,833	19	11

Therefore the cost of the works up to March 31, 1901, stands at 47,833*l.* 19*s.* 11*d.* At the present time the Author is engaged in carrying out the erection of a new retort house and coal store, etc., estimated to cost 2000*l.*, Alfred Colson, Esq., M. Inst. C.E., being the consulting engineer.

The statement on following page will show at a glance the progress made since the purchase of the works by the Council (the amount repaid for loans and interest being 1842*l.*).

Private Street Works.

During the past three years the Author has made up seven private streets under the Private Street Works Act, 1892, and has at the present time fourteen others in course of construction; he has also prepared plans and specifications, etc., for the making up of a further batch of twenty others.

The Council have in every case assisted the property owners, where the streets have been in existence any length of time and built up, by paying the whole cost of storm-water sewers, gullies, branch drains and street lighting; the average amount charged to the owners has been about 20*s.* per yard lineal on a 30-foot street.

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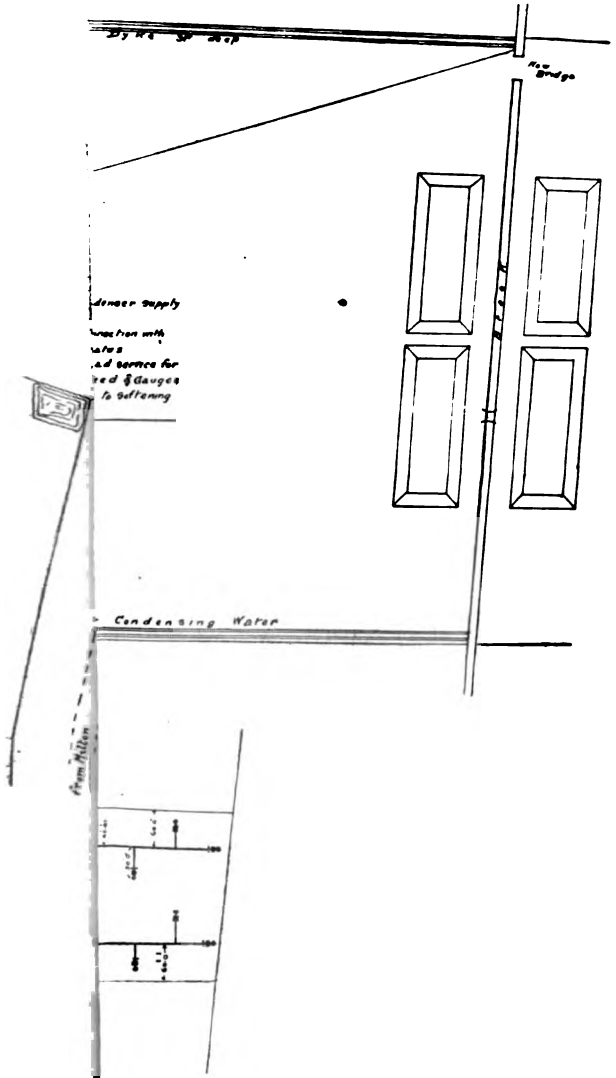
PLATE I.



RAL PLAN OF THE WORKS.

p. 16—i.

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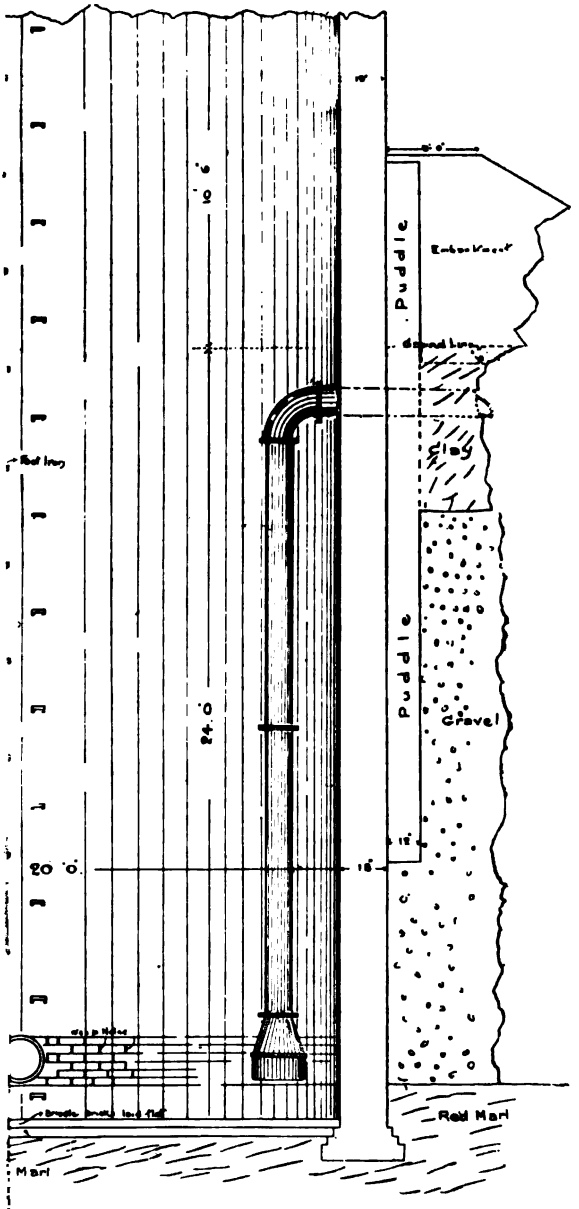

Scale 1" to 1'.

OF WELL.

LA-ZOUCH JOINT WATERWORKS.

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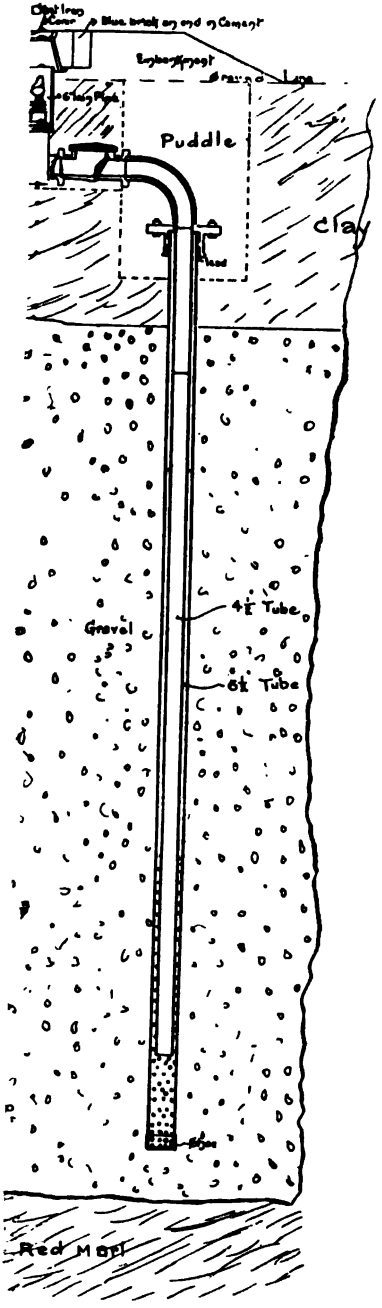
PLATE III.



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ON OF BOREHOLES.

-DE-LA-ZOUCH JOINT WATERWORKS

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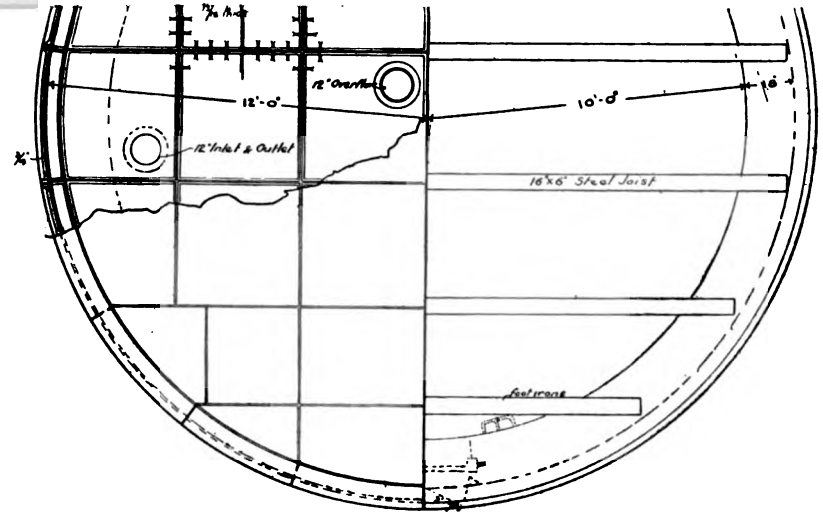

SWADLINCOTE AND ASHBY-DE-LA-ZOUCH JOINT WATERWORKS.

PLATE IV.

p. 16—iv.

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TABULATED STATEMENT SHOWING THE GROWTH OF THE GAS-WORKS SINCE THE PURCHASE BY THE URBAN DISTRICT COUNCIL.

Year.	Coal Used.	Gas made per Ton.	Cost of Coal.	Wages.		Gas Made.	Gas Sold.	Gas used on Works.	Gas Lost.	Sales of Gas.		Rent of Meters and Stoves.	Sundry Sales.	Cash Sales.	Total Sales.
				Gas Making.	Other Wages.					Prepaid Meters.	Ordinary Meters.				
	tons.	cub. feet	£ s. d.	£ s. d.	£ s. d.	cubic feet	cubic feet	cubic feet 1¼ per cent. on make	cubic feet	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1897–8	2773	9014	1557 5 6 (equal to 1s. 3d. per 1000 ft.)	476 6 3 (equal to 4¼d. per 1000 ft.)	332 9 9	24,997,800	18,109,700	374,966	6,513,134 (equal to 26 per cent. of make)	153 9 2	3399 15 4	124 6 0	891 14 3	169 19 11	4739 4 8
1898–9	3187	8526	1886 11 10 (equal to 1s. 4½d. per 1000 ft.)	421 3 0 (equal to 3⅜d. per 1000 ft.)	458 19 11	27,172,900	20,816,000	407,593	5,949,307 (equal to 22 per cent. of make)	295 12 8	3793 1 11	132 18 5	812 14 5	168 8 11	5202 16 4
1899–1900	4110	7338	2582 8 0 (equal to 1s. 8¼d. per 1000 ft.)	590 16 0 (equal to 4¾d. per 1000 ft.)	478 10 2	30,159,200	23,084,700	452,388	6,622,112 (equal to 22 per cent. of make)	588 17 0	3·66 8 6	158 2 4	1063 6 4	216 6 11	5893 1 1
1900–1	3913	9007	3248 13 4 (equal to 1s. 10d. per 1000 ft.)	638 17 6 (equal to 4½d. per 1000 ft.)	624 5 9	35,247,000	26,669,300	528,705	8,248,995 (equal to 23 per cent. of make)	1050 8 10	4279 13 3	186 11 0	1536 7 2	285 6 5	7338 6 8

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The question of building new public offices, town hall and market premises is under consideration by the Council. Plans have also been prepared for the erection of a new depôt, including engine house, workshops, stabling, cart sheds, and tar paving mixing sheds, with hot floor for evaporating the moisture out of the materials. These have been approved and loans sanctioned by the Local Government Board.

Joint Water-Works at Milton.

The works were designed by Messrs. G. and F. W. Hodson, civil engineers, to supply a population of 27,000 persons at 20 gallons per head per day or 540,000 gallons in twelve hours, and are situated 132 feet above Ordnance Datum on the low lying grounds extending from Milton village to the river Trent, near Twyford ferry, in the county of Derby, seven miles to the north of Swadlincote and about six miles to the east of Burton-on-Trent.

In adopting this site, which is about 620 yards from the river Trent, very careful consideration was given to the question of the possibility of the pollution of the water by infiltration from the Trent.

The preliminary borings proved most difficult, and occupied considerable time.

The Bunter conglomerate—according to the geological plans—occupies the surface from Repton Shrubs to the Milton village, and from thence extends from the private road leading to Foremark Hall, where it disappears under the gravels of the valley of the Trent.

It was expected that by boring on the site, which is about 900 yards to the north of this roadway, after passing through the gravel beds, the Bunter conglomerate would be reached; however, such was not the case, for the borings proved that a downthrow fault existed between Foremark Road and the site, and the Bunter conglomerate, instead of being reached just below the gravel, was proved to be covered up by the Keuper and was not met until a depth of 100 feet had been reached. It was found to be an intensely hard mass of boulders, so much so that the boring, being at the rate of 1 to 6 inches per day, was a very slow process. As it is of rare

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occurrence for these conglomerates to extend to any considerable thickness, the boring was continued until a depth of 170 feet had been reached without passing through into the softer rock. The operation was therefore stopped and samples of water taken for analysis from the upper gravel beds and the deep boring, and submitted to the late Dr. Tidy, who after full consideration pronounced both waters to be of excellent quality, very free from organic matter, and well fitted for a town supply, the water from the gravels being the better of the two.

The hardness of the deep seated water being 20°·12 before boiling, and 6°·64 after, whilst the water from the upper gravels was only 15°·89 before boiling and 4°·69 after, in order to reduce the hardness it was decided to adopt the Archbutt-Deeley softening process, the hardness at that time being principally due to carbonates and not to the sulphate of lime.

The selected site is stated to possess three distinct sources of supply:

The first, from the gravel beds, is in a measure supplied with water from the sandstone area on the high lands, which flows over the lip of the clay fault, proved by borings. The second is water from the Bunter conglomerate formation underlying the clay, which is reached at 100 feet; and the third is the water of the stream which takes its rise on the slopes of Coppice Farm and the Pistern Hills, flows through Foremark Bottoms to the east of Milton, and, after passing through the site where the Joint Committee are riparian owners on both sides of the stream, falls into the Trent.

The Author may say the Milton Brook watershed is capable alone of yielding from 2 to 2¼ million gallons of water per day; it carries but a scanty population, and is probably freer from chance of sewage pollution than any stream within many miles of the district supplied.

The first named scheme was carried out, and thus saved the cost of impounding, which would not have been less than 100,000*l*.

The works for abstracting the water are of the simplest nature, and consist of a series of Abyssinian tube wells distributed over the site in such a manner as to intercept the upland waters, and by the construction of filter tunnels through the adjoining lands.

The low-lying ground at Milton consists principally of a

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stratum of gravel and sand, which was met with in the test bore-holes at depths varying from 16 to 23 feet below the surface and overlying the Keuper marl. Into this bed of gravel, there are about thirty bore-holes put down, each lined with 6½-inch external diameter wrought-iron artesian well boring tubes with flush joints.

The tubes have steel shoes fitted at the bottom, galvanised, and are drilled throughout the lower 6 feet with ½-inch holes set out diagonally at 1½-inch centre to centre.

Test holes proved that the underlying red marl had been eroded before the deposition of the gravel, consequently it was impossible to state the exact depth of each bore-hole. A small pioneer boring was therefore put down to test the depth to the marl in every case, so that the exact length of the 6½-inch lining tubes could be determined, and the tubes made at the works suitable for each hole. These are made in two lengths, the upper being fitted with a cast-iron double collar joint with flanged top faced in the lathe, and to fit the flange of a 4½-inch metal suction pipe similarly faced, which extends to within 12 inches of the bottom of the hole; the flange is arranged to receive the bend of the 4-inch suction pipe leading into the 9-inch collecting suction main.

The flange pipes terminate 3 feet below the level of the surface. The ground was excavated 12 inches below the level of the flange and filled in solidly with puddle in such a manner as to prevent infiltration of water down the sides of the tubes.

Centrifugal pumps with 4-inch suction and delivery pipes, capable of discharging 200 gallons per minute, fitted with a temporary 4-inch suction pipe extending to nearly the bottom of the bore-hole, were provided to pump from each boring after it was made, to the full capacity of its yield (for forty-eight hours) continuously, or until such time as the water became perfectly bright, clear and free from sand; the water so pumped was delivered into a properly constructed gauging pond by means of wooden troughs, so that the yield from each could be made to flow into it for its proper measurement. The pond was fitted with an automatic indicator, furnished by the engineers, Messrs. G. and F. W. Hodson, capable of making an automatic record of the quantity of water so pumped.

The well is 20 feet internal diameter, and is sunk through the gravel, which was found to be 23 feet in thickness down to

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the red marl. The floor is paved with two courses of brindled blue bricks laid flat in cement mortar. The walls are 18 inches in thickness and built of brindled blue brick set in cement mortar, and are carried up 18 feet above the original level of the site, and surmounted by a cast-iron circular tank 24 feet in diameter and 9 feet deep inside, supported on six 16 in. by 6 in. steel girders. There are 27 plates in the tank, each weighing 5½ cwt. A 12-inch cast-iron pumping main, from the termination of the low-level delivery pipe to the circular tank inlet, is connected also to the inlet of the softening tanks.

A 12-inch suction pipe from the low-level pumps is carried to the bottom of the circular well and fitted with a Tangyes 12-inch foot-valve.

Filter tunnels were constructed and formed by excavating close timbered trenches down to the marl; all undulations were cut through so as to allow a true gradient of 1 in 300 throughout. The sanitary pipes are 15 inches in diameter and of the best quality manufactured in the Swadlincote district, pierced with holes over their whole bodies, 1½ inches apart, ⅛ of an inch in diameter.

The pipes were surrounded with pea gravel screened from the excavation, and the upper part of the trench was filled in with a layer of clay puddle 18 inches thick.

Steam pumping power, capable of raising 1500 gallons per minute, was arranged and connected from time to time for testing the yield of each series of borings, also the aggregate yield from all sources.

The bore-hole suction mains are 9 inches in diameter, 9 feet long, and ⅝ inch metal in body of pipes, laid with true gradients 2 feet 9 inches below the level of the ground. The bore-hole connections are made with 4-inch off 9-inch arm pipes fitted in the main suction pipe, each of these branch suction pipes being fitted with a 4-inch sluice valve and 4-inch reflux valve with G.M. faces.

Special 9-inch four-way flanged armed pipes and 9-inch sluice valves are provided and fixed on the line of the main suction pipes for bye-passing purposes.

A quantity of the excavation was found to consist of the alluvial warp, or clay. The best portion of this was carefully selected and tempered to make puddle, which was well knit into the trenches until they were perfectly water-tight. Where the

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pipes cross under the brook, they are embedded solidly in Portland cement concrete, and puddle stops inserted to prevent the access of water from the brook into the pipe trenches.

The machinery is by Messrs. Tangyes, Limited, Birmingham, and has been designed with a special view to economy of coal consumption and the reduction of working expenses in every possible way according to the best engineering practice of the present day.

The low-duty plant draws from the well and bore-holes and delivers into the hard-water tank and consists of:

No. 1.—12-inch by 16-inch double-acting well pump, capable of delivering a maximum quantity of 30,000 gallons per hour.

No. 2.—8½-inch by 16-inch double-acting bore-hole pumps, each capable of delivering a maximum quantity of 15,000 gallons per hour. The speed of pumps when the maximum quantities are being delivered is about 40 revolutions per minute; the total lift about 51 feet, exclusive of friction. All three pumps deliver through one 12-inch main into the hard-water tank.

One reflux valve is fitted on the delivery of each pump before it reaches the main, to prevent loss in the event of stoppage of one of the pumps. All three are brass lined, with gun-metal leather-packed buckets, Muntz metal rods, india-rubber valves working on gun-metal seats; each fitted with an air vessel on delivery and a bye-pass.

The cross-heads are made of malleable iron, working in slipper guides bolted to pump bases fitted with steel pins secured by cones and nuts. The connecting rods are of wrought iron, with adjustable gun-metal bearings at each end. The above pumps are bolted to one cast-iron base plate, on which are cast five chairs fitted with gun-metal bearings for the crank shaft.

The three-throw steel crank shaft is made in two parts, the cranks are slotted out, the outer end of the shaft carries a cast-iron disc for the engine crank pins.

There are two 10½-inch by 22-inch horizontal condensing engines 100 lbs. series, with steam-jacketed cylinders having short ports, with Meyers' variable expansion gear, adjustable by hand whilst working. The cylinders are lagged with sheet steel, fitted with sight-feed lubricators, the necessary drain cocks, indicator cocks and pipes; the fly-wheels are 90 inches by 13 inches, and weigh 30 cwt. fitted with barring gear, Soho

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governors, etc. The hand-wheels of governors are on the engine-house floor, to enable these engines to be started and stopped without going down into the basement.

The water, after being treated and softened, is pumped through a 12-inch rising main to the Woodville reservoir, by the high duty plant, consisting of:

Two tandem compound horizontal condensing engines of the girder type. High-pressure cylinder 14¼ inches diameter, low-pressure cylinder 23 inches diameter by 36 inches stroke; both cylinders are steam jacketed.

The high-pressure cylinders have short ports with double slide valves, fitted with separate expansion valves on Meyers' system, adjustable by hand. The low-pressure cylinders have "trick" slide valves, arranged to cut off at about half stroke, and are connected to the high-pressure cylinders by wrought-iron stays.

The receivers are provided with suitable pipes and cocks to allow for high-pressure steam being admitted when starting the engines; the cross-head guides are fixed upon cast-iron supports.

The cross-head pins are made of steel 3⅞ inches diameter and 6¼ inches wide, secured by cones and nuts. Cast-iron bases are provided to carry the high- and low-pressure cylinder of each engine. The fly-wheels are 12 feet diameter and 20-inch face, made in halves, each weighing about six tons and fitted with hand barring gear.

The crank shafts are of steel; one end is fitted with cast-iron discs and steel pins, and upon the other end of the shafting three cranks are forged, having throws slotted out for working direct by connecting rods without the intervention of gearing.

Two sets 9½-inch by 15-inch treble ram-pumps are provided, and when working together are capable of delivering 45,000 gallons per hour to a vertical height of 420 feet through the rising main, or, including friction, against a total head of 535 feet when running at a maximum speed of 36 revolutions per minute. The rams are of cast iron, working through gun-metal bushes with separate cast-iron pump-barrels, each having valve boxes cast on, fitted with doubleway gun-metal suction and delivery valves with bye-pass arrangement and a cast-iron air vessel on delivery.

The pump cross-heads are formed on the ends of the rams, working in slipper guides and fitted with steel pins.

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The connecting-rods are of wrought iron, fitted with adjustable gun-metal bearings at each end, 3 feet 9 inches between centres.

The pumps, with crank shaft and slipper guides, are carried on a cast-iron base plate. The crank shaft is carried in four gun-metal adjustable bearings.

There is also an independent jet condensing plant, consisting of one 9 in. by 14 in. gun-metal lined air pump with gun-metal bucket, india-rubber valves working on G.M. seats, injection cock and spray pipe, and driven by the extension of the piston rod from a horizontal steam engine of the Tangye type. The cylinder is short-ported, 5½ inches diameter and 14-inch stroke, and fitted with Meyers' variable expansion gear.

The piston is of cast iron, packed with spring rings, and has a steel piston rod 1⅜-inch diameter.

The exhaust is so arranged for working direct to the atmosphere or into the condenser.

Softening Process and Apparatus.—The whole of the softening plant was supplied and fixed by Messrs. Mather and Platt, engineers, Salford Iron Works, Manchester.

Much has been said and written of late years on water softening, therefore the Author does not propose to go into the question, but simply give a brief description of the Archbutt-Deeley process in operation at these works, which has given every satisfaction.

The Author may say at this point, since the works were brought into full operation the water has undergone a change, the hardness being now not less than 26°, and besides being very hard contains in solution a certain amount of iron, which precipitates on exposure of the water to light and air. The iron is successfully and completely removed, the hardness of the water being reduced from 26 degrees to an average of 9 degrees.

Hard water, so called on account of its soap-destroying property, owes its peculiarities to the presence of compounds of lime and magnesia, principally the carbonates and sulphates, also occasionally the chlorides and nitrates.

Dr. Clark has shown how, by adding one ounce of quick lime to 1000 gallons of water for each degree of hardness the water will be rendered clear, soft and quite fit for drinking purposes in twelve hours' time.

The mechanical operations involved with the softening and

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purification of hard water by the Archbutt-Deeley process include the preparation of the reagent, the mixing it with the hard water, the separation of the precipitate and the subsequent bi-carbonating of the softened water.

The apparatus and process employed is of the simplest possible character compatible with efficiency, and is applicable to the removal of both temporary and permanent hardness. Plain tanks are used and filters are not necessary, for by a special method of manipulation it has been found possible to increase the rate of subsidence of the precipitate to such an extent that about one-sixth of the tank area required in Clark's process has been found sufficient.

This effect is produced chiefly by the simple expedient of stirring up, every time a tankful of water is softened, some of the precipitate which has settled from the previous operations.

This precipitate by lying at the bottom of the tank becomes aggregated into coarse flakes, which, when stirred up and allowed to settle again carry down the fine particles of fresh precipitate so rapidly that in less than thirty-five minutes the water clears itself to such an extent that the suspended matter remaining even at a depth of 6 feet from the surface does not exceed 1 grain per gallon.

The apparatus is designed to treat 45,000 gallons per hour or 540,000 in twelve hours, which is easily softened and purified in four tanks 10½ feet deep, each having a working capacity of 27,000 gallons, being ¾ of its depth, about 2½ feet of water and mud being allowed to remain when the water is drawn off, while a margin of 6 inches at the top is left in filling, which is done by means of a supply pipe from the hard-water tank.

The quantity of water being thus exactly known, the proper quantities of quick lime and anhydrous carbonate of soda (58 per cent. alkali) are weighed out accordingly.

The lime is first slaked in hot water in one of the small reagent tanks, which is 3 feet in diameter and 3 feet high, and the same being filled with water from a tap connected with the rising main or may be connected direct from the softening tank by means of the tee and pipe between the three-way tap A and blower B by turning on steam to the blower, throttling the passage through the three-way tap to the two vertical downward pipes G and K, and opening the tap D, the tap E and the air tap being closed; water is then lifted into the tank through the rose

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and suction pipe. The water is boiled by a perforated steam coil. After the lime has been completely slaked the alkali is added and the liquid is boiled for a period of two minutes, and stirred until the alkali is dissolved.

The reagent thus prepared is injected into the hard water through the upper row of horizontal perforated pipes, in the following manner. The tap D and the air tap being closed, steam at not less than 60 pounds pressure is admitted to the blower B, and the three-way tap A is turned so that a current of water is established from the softening tank through the rose J, the suction pipe S, and the three-way tap down the vertical pipe G and back into the tank through the perforations on the upper side of the upper row of horizontal pipes. Into this current of water the reagent solution is slowly admitted by opening the tap E, and is diffused throughout the volume of hard water in the softening tank.

The operation, including the washing of the reagent tank, generally occupies ten minutes.

The suction pipe in the reagent tank is fixed inside a 4½-inch wrought-iron tube with holes perforated over the whole body, a blank flange being fitted at the base which prevents any piece of ash or stone, etc., sometimes found in the lime, from getting into the blower or perforated pipes in the softening tanks.

The tap D having been shut off, the air tap over the blower B opened and the three-way tap A reversed, air is forced down the pipe K and through the perforations in the under side of the lower row of pipes into the mud at the bottom of the tank, stirring up a portion of the mud and diffusing it through the water.

After the blower has been in operation for three minutes the steam is shut off, and in about thirty-five minutes the water is perfectly clear and ready to be drawn off and fit for domestic use.

The operation of carbonating and drawing off are effected simultaneously by means of a floating arm the body of which is of copper 8 inches by 14 inches in section, having baffle or angle plates fixed at intervals along the bottom; these cause the water to flow down through the arm giving a cascade motion, splashing up into the gases which are injected from the coke-stove into the cast-iron head of the floating arm through the gas pipe N.

The water and surplus gas escape together at the lower end through the ball valve; the carbonated water falling into the

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reservoir from which it is pumped by the H.D. plant to Woodville reservoir, and the gas escaping into the air through a series of air grates fixed immediately under the softening tanks. The coke stove contains in the upper part a supply of coke which, by falling through a special cast-iron cone, maintains a fire of constant thickness over the fire-bars; the top of the chimney is closed by a wing valve, below which the gas is drawn off through a branch for carbonating purposes. In order to ensure a constant and ample supply of gas, a ½-inch blower is fixed in the branch pipe.

When the ball valve closes and water ceases to flow down the discharge pipe, the gas accumulating in the head of the pipe forces the water below the weir M and escapes through the pipe O without disturbing the water in the tank.

When the ball valve again opens, the floating arm first empties itself of water and the gas then escapes through the ball valve, relieving the pressure and allowing the water to again pass over the weir M, and down the floating arm with the gas so long as the valve remains open.

The precipitate is prevented from accumulating in the tanks by its partial removal at stated intervals, and from the nature of the precipitate and the fact that it is not allowed to consolidate it is easily dealt with—it being swept out into a pipe which conveys it into shallow draining pits to stiffen, and is then carted away.

The buildings—which consist of an engine house, 36 feet by 34 feet; boiler house, 41 feet by 22 feet; fitting shop, 16 feet by 12 feet; capacious coal store, 39 feet by 12 feet; softening room; engineer's cottage; lime and oil stores—are raised above the highest known flood level, and embanked all round.

The engine chimney is 80 feet high, 3 feet 6 inches wide inside at the bottom, and 2 feet 6 inches wide at the top.

The reservoir, which has a capacity of over 1,000,000 gallons, is situate to the north-east of Woodville at an elevation of 550 feet above O.D., and was owned by the Burton Union Rural Sanitary Authority until the amalgamation of Swadlincote, Gresley, Stanton and Newhall into a united Local Government area—the effect of the amalgamation being that the Gresley Water-Works became vested in the Swadlincote District Local Board, now the Swadlincote Urban District Council.

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One of Messrs. Jennings and Brewer's electro mechanical apparatus for indicating and registering the varying levels of water in the reservoir has been fixed, and proved of very great service.

The apparatus consists of two separate instruments, one (the transmitter) being placed at the reservoir, the other (the receiver) fixed at the engine house, the two instruments being connected by a single line wire, carried overhead on poles.

The transmitter, with its battery, is placed on an iron bed-plate fixed on the top of an iron cylinder, containing the float in a convenient position at the reservoir and above high-water level, and is enclosed in a cast-iron case and protected by a locked cover.

A chain passes over a grooved wheel and is attached to a copper float and counterpoise, the float rising and falling with variations of the level of water in the reservoir.

The spindle on which the chain wheel is fixed carries another wheel, which gears into a pinion fixed to a second spindle, the ratio of the teeth being such, that for every inch rise or fall of the water, the pinion makes one half revolution.

The pinion spindle carries a double arm, which at every half revolution pushes back a lever, at the end of which is an adjustable weight, giving the motive power, and when a locking-lever at the side of the movement is pushed back by a cam on the second spindle (previously referred to), releases a vulcanited wheel, cut in the shape of a double snail, and in revolving on half its diameter depresses two springs, and completing the circuit between the transmitter battery and the receiving instruments at the engine house.

The receiving instrument consists of two powerful electro-magnets of special design, being only a single coil, one each working the rise and the other the fall in the movements, and connected by a vertical rod to two horizontal levers at the end of which is a projecting pin, arranged so as to drive or actuate a pair of rachet wheels fixed on spindles and geared together and connected to the movement of indicator, these wheels having their teeth cut right and left, so that when the current is received by one of the coils the pointers on the dial-face are revolved in one direction indicating a rise, and when received by the opposite coil the pointers revolve in the opposite direction indicating a fall; a detent in connection with the

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rachet wheels completing the action after the electric current has left the coil, so that only one tooth at the time can pass.

The relays in these instruments are of the latest type, and have special means for adjustment according to length of line wire.

The needle is held in position and polarised by a permanent magnet, and on the end of each pole is an adjustable armature to increase or decrease the magnetism of the needle; also the electro line magnet has the same means of adjustment, by adjustable pole pieces at their ends, so that they can be brought to or from the needle and actuate the attraction or repulsion during passage of current along the line, according to the distance from the reservoir.

Name of Contractor.	Contract.	Particulars of Contract.	Cost of Works. Cost of each.			Total cost of works.		
			£	s.	d.	£	s.	d.
Messrs. Graham and Sons	No. 1	For sinking well boreholes and filter tunnels	3,467	13	2			
Mr. J. Tomlinson	No. 2	For pumping station and mains	16,235	11	11			
Messrs. Tangyes, Limited		Engines and machinery	4,362	8	0			
Messrs. Stanton, Iron Co.		Cast-iron tanks	990	3	4			
Messrs. Mather and Platt		Archbutt-Deeley softening apparatus	750	0	0			
Mr. J. Tomlinson		Alterations of reservoir, including new 12-inch main over reservoir bank, new 8-inch outlet for Ashby main, 12-inch bye-pass, balancing chamber, wash-out, &c.	664	14	3			
Mr. J. Tomlinson		For water meters fixed on Swadlincote and Ashby mains	213	15	0	26,684	5	8
Engineer's charges, easements, valuer's fees, purchase of land, etc.			2,346	8	11			
Advertising, legal expenses, expert evidence, etc.			121	14	5			
			2,468	3	4			
Valuation of Gresley reservoir, taken over by joint authority from Swadlincote Council ..			1,350	0	0	3,818	3	4
					£	30,502	9	0

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A recorder is fitted to the receiving instrument to record the level in inches of water, and marked by means of an aniline ink pen on a diagram fixed on a revolving drum, the drum being connected to an eight-day clock. The diagrams are ruled and divided into hours horizontally and feet vertically, the pen marking the inches at every movement of the dial pointers.

The diagrams are replaced every seven days.

Telephonic communications are provided between the Milton Works, the Author's office and Woodville reservoir.

The works were carried out by the contractors given on preceding page.

The Joint Water Authority is constituted of twelve members, eight from the Swadlincote District Council, and four from Ashby-de-la-Zouch Council, by virtue of an agreement by which the Swadlincote district provided three-quarters of the capital expended, and Ashby one-quarter.

The allocation of working expenses to be borne by each authority is based upon the quantity of water consumed in their respective districts.

DISCUSSION.

Mr. J. Price: I have much pleasure in proposing a hearty vote of thanks to Mr. Kidd for the very excellent and detailed paper he has read to-day. It refers to a district which has certainly been progressive: no great jumps, but still steadily increasing in population. It is evident that the Urban District Council since the amalgamation has been successful. At any rate the death rate would seem to show that; because in the year 1894 it stands at 17·57, and in 1900 it has dropped to 14·46, a decrease which points to useful sanitary work. No doubt some of the bye-laws made in 1871 are useful, and can be carried out with advantage to the district, but having in view the fact that certain Acts of Parliament with reference to the public health have been passed since then, if the bye-laws have not been amended since that date, there are certain powers which this Council is not able to carry out, but which would, perhaps, be useful to a district of this character. That the Urban District Council have not been behind-hand in facing necessary expenditure can be seen by the spending of 30,000*l.* on sewerage and sewage disposal works—work which comes out

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at 2*l.* per head of the population, which is considered rather heavy. I should like to know if there are any storm overflows on the sewers, and at what rate of discharge those storm overflows are calculated to act. With regard to the sewage farm, I should like to ask why 9-inch under-drains are used instead of 6-inch: 9-inch pipes seems an abnormal size to use; perhaps there is good reason for it. I should also like to know whether after putting down your sub-drains you provided for air-drains, because the sub-drains, to act effectively, must have air. With respect to scavenging, I notice the Council have very properly decided to have a refuse destructor. There are no details given of that, although the Author says he has prepared plans. I should like to know the number of cells proposed. As to public lighting, I should like to have the number of hours the lamps are lighted per annum, the cost of the gas, and the cost per lamp for everything. I am not touching upon the water supply, because there are some gentlemen here present who have special knowledge of that subject. With regard to private street works, the Council seems to have adopted a policy of compromise, because in dealing with the making up of new streets they have paid a proportion of the cost; I should like to know why they have elected to pay for street lighting as one of the items. On looking through the tabulated statement of the gas-works, one cannot help noticing the very large apparent leakage, equal to 23 per cent. of the make, if I read the figures correctly. I suppose there must be some particular reason for that, which Mr. Kidd will give to the meeting, and which may prove very useful. The average is about 5 per cent. In Liverpool it is only 4 per cent., and Mr. Greatorex, who called my attention to this, mentioned that at West Bromwich it is only 4·36 per cent. I think that the provision of proper offices for a town which can spend all this money on useful public works is very necessary.

Mr. C. F. Wike: I have pleasure in seconding the vote of thanks to Mr. Kidd, who has given us a paper full of facts and information. I should like to refer briefly to one or two of the points he has raised. First with respect to sewage disposal, I notice the Author says only 20*l.* 18*s.* 8*d.* has to be provided out of the rates for the farm, and it would be of interest to know whether this is after paying interest and sinking fund on the loan. Mr. Kidd might also tell us whether he has experienced

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difficulty in treating any of the trade effluents upon the farm. Another question is that of private street works. In Sheffield we have about 90 miles of undedicated streets (many of which are of course not ripe for dedication), and we have adopted various forms of construction with the idea of meeting the property owners who have to pay the cost. It is, however, most difficult to arrive at a specification which will please those who have to pay and also ensure a sufficiently permanent class of work. There is no doubt that the adoption of a low standard in the past is one of the causes of the present high rates, as streets have been taken over which have soon had to be repaired at the public expense, instead of lasting for a fairly long period as such streets ought to do. Mr. Kidd puts down the cost of his private street works at 1*l.* per yard, but I do not know whether this is of frontage or street. In Sheffield at present the standard price for a 40-foot street, with flagged foot-paths and paved carriageway, is about 6*l.* per yard of street, so there is a wide difference between us. I should also like to ask if any rebates are allowed to property owners. In Sheffield we have done this many times, though it is held by some that such a course is not legal, and that the ratepayers should not be charged with such costs. Mr. Kidd also referred to the provision of duplicate sewers for storm-water, and I should be glad to know if this can be compelled. I know the same thing is being done in Leicester. When I was there a whole district was sewered on the duplicate system, but the streets were dedicated ones and the expense did not fall upon the owners; and I doubt whether such a requirement can be enforced with regard to new streets without special Parliamentary powers.

Mr. J. T. Eayrs: I should like to call attention to the enormous amount of gas which is unaccounted for. The quantity given in the paper as leakage shows there is something very radically wrong in the gas-works of this town. It is as well to call attention to that because it may possibly lead to its being remedied. At present the gas-works are apparently not a very profitable undertaking, although the rate is over 4*s.* per thousand cubic feet. It must, of course, be borne in mind that there are no gas engines or motors supplied, and that the works have to depend upon a supply for purely lighting purposes. With respect to the water supply, the consumption is about 10 gallons per head per day. I assume this is measured by meter. That

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is a point Members should take note of, because when we have to deal with the Local Government Board as to sewage, the water consumption is very often greatly over-estimated. I think about 12 gallons per head per day is quite sufficient for domestic consumption. I do not know whether any manufacturers are using water, and whether that is included in the 10 gallons. I have an instance in my mind of a place similar to this where the water supply was 8 gallons per head and they had an effective supply, though the pressure was not very great. There were no water-closets in that town. I saw in one of our professional newspapers yesterday mention of a town where the water supply is only 7 gallons per head per day, which is exceptionally small.

Mr. A. D. Greatorex: I did call the attention of Mr. Price to the enormous loss of gas shown in the paper, and as my name has been mentioned, I should like to quote from a report presented to the Gas Committee of West Bromwich, which is a mining town. The amount of gas made last year was 327,468,000 cubic feet, and the loss from leakage 4·36 per cent. For the excessive loss mentioned in the paper there must be some reason, and it will pay the Council to find it out and remedy it. I should like to congratulate Mr. Kidd on the working of the sewage farm; to have a loss of only 20*l.* 18*s.* 8*d.* a year is a very good result indeed. I also should like to know why they used 9-inch pipes for under-drains. I have carried out under-drainage works on the West Bromwich farm and only used 6-inch pipes. What is the quantity of sewage dealt with in twenty-four hours; is it entirely sewage, or is any rainfall taken to the farm? I should like to see the analysis of the effluent. I should also like to know the cost of the electric lighting, for Mr. Kidd says the remainder of the lamps are lighted by electricity. What lamps are used, what is their candle-power, their cost per night or per annum, and their cost for maintenance; also what do the Council charge for water used for road-watering purposes?

Mr. S. S. Platt: There are one or two points in the paper which might be elucidated. With respect to the birth and death-rate of the district, is the information given based on the estimated population, or has it been revised at all by the recent census returns?—because if not the figures are likely to be rather misleading. A point to which the District Council

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might direct their attention is the zymotic death-rate. The ordinary death-rate is low; but the zymotic death-rate can be brought down. As to the cost of sewerage and sewage disposal works, I do not think the Council ought to consider the price excessive; 2*l.* per head is not an excessive price when dealing with a small population. In dealing with a population of 100,000 or 500,000 it is a different thing. I must also congratulate Mr. Kidd on the good results of his sewage farm. If he can work the farm and get a good effluent with only a loss of 20*l.* a year, he is doing very well indeed. With regard to the water consumption of 10 gallons per head per day, I should like to know whether it is based on the population of the district or the population served. You may have here a poor population not very luxurious as to bath and water-closets. As to private street works, under the exceptional circumstances which prevail here, and the concessions given by the Council to property owners, the cost is no criterion as compared with other places. In my own district the Corporation do not pay the cost of sewers, gullies and branch drains, nor does street lighting come into the account. In the ordinary streets in my district, the cost is 50*s.* per lineal yard of frontage instead of 20*s.* It is a mistaken policy to relieve the property owners in this way. It will come back to the Council in the future, and they will find they have relieved the property owners at the cost of the general ratepayers. The streets cannot be kept up at this price. I should like Mr. Kidd to give the cost of the softening process per thousand gallons of water. I think the Author is to be congratulated upon having prepared an excellent paper, containing a lot of valuable information.

Mr. G. T. LYNAM: There are two things in the paper which appeal to me: they are the cost of construction of private streets, and the very small quantity of water consumed per head of population. Mr. Kidd was speaking to me a few days ago about the cost of private streets, and after making allowance for the concessions given here, I still failed to find out how he makes a street for 1*l.* a yard. It would be interesting to know in what way he makes up the streets, the footpaths, the kerbs, and the carriageways. With respect to the water supply, a consumption of 10 gallons per head per day is a very reasonable amount for domestic purposes, but surely that cannot include any consumption for trade purposes. In Burton-on-

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Trent the cost of making the macadamised streets is between 4*l.* and 5*l.* per yard; that includes two sewers, but no lighting.

The PRESIDENT: If ever there was a place where a man was burdened with a variety of work, it is Swadlincote: he is borough engineer, gas engineer, electric light engineer, and water engineer, and I should think he gets a very good salary. I have attended a great many district meetings, but I do not think I have ever heard a greater volley of questions than I have heard to-day. With respect to private street works, we do not charge the owners in Leicester with the cost of street lighting; we do the lighting, and I understand that is what is done in Swadlincote. With regard to the two sets of sewers, we have regulations enforcing this system in Leicester. A question was raised about the local authority paying for sewerage when they have served notices under Section 150. If we come across an old street which was made before we had dual sewers, we put in the dual sewers and provide the manholes. So we do meet the owners in that way. Then if the original plans were for macadam, ten, fifteen or twenty years ago, and we want anything else and serve notices under Section 150, we must pay for it ourselves. There is another matter with respect to the cost of making new streets. It is hardly fair to compare the cost in Birmingham, Leicester and Sheffield with the cost in Swadlincote, because the streets are narrower and not so expensive. The price Mr. Wike mentioned is a fair price in Sheffield, but would not apply here.

COMMUNICATED REPLY FROM MR. KIDD.

In reply to Mr. PRICE:

The high rate per head of the population for sewerage and sewage disposal is to a very great extent accounted for by the straggling districts, which are not yet built upon, although sewers are laid. Overflows are provided on the sewers, and come into operation after the sewage has been diluted about ten times its volume.

As to the Under-Drains.—I quite agree with Mr. Price and other speakers that 9-inch pipes are an abnormal size; 6-inch pipes would have been preferable.

Destructor.—The destructor is designed for two three-grate units, representing six cells.

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Street Lighting.—The street lamps are lighted 1540 hours per annum, and cost 1*l.* 15*s.* per lamp, which includes gas lighting, repairs, painting and maintenance. Gas for street lighting is 3*s.*, and for other purposes 4*s.* 2*d.* per 1000 cubic feet; the latter is subject to 2½ per cent. discount if paid before the expiration of the quarter following.

Electric Lighting.—32 c.p. Ediswan lamps 90 to 100 volts are used in connection with the Stanton lighting, and cost 25*s.* per lamp per annum.

Unaccounted-for Gas.—We are aware that this percentage is very high, and the Council are resolved to do their utmost to reduce it; the loss is accounted for in many ways, and includes:

(*a*) Gas used on the works not registered. (*b*) Loss when new services and mains are being connected. (*c*) Loss caused through broken mains and services through subsidence of ground by mining operations. (*d*) The gas at times varies between the registration of the station and the consumers' meters; the former is probably correct, but the latter are allowed by law a variation of 5 per cent., that is 2 per cent. against the consumer, and 3 per cent. against the supplier of gas. (*e*) Then, again, the gas at times as it passes the station meter is at a much higher temperature than when it reaches the consumers' meters. (*f*) Dry meters vary considerably, and at times register incorrectly. (*g*) The gas consumed for street lighting for the whole 400 lamps is based on the average readings of six meters, which is totally inadequate; to arrive at a fair average consumption per lamp one meter should be allowed to every eight lamps. (*h*) And lastly we have some very old defective mains in various parts of this district.

Private Streets.—I may say the private streets now being made up are very old ones, and originally formed part of the rural district of Burton-on-Trent. At the amalgamation, my Council were of opinion the owners who had paid rates for property situate therein for upwards of thirty years, were entitled to some consideration and assistance, hence they agreed to pay for lighting, sewers, branch drains and gulleys. There was no special reason for including the street lighting.

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In reply to Mr. WIKE:

Sewage Disposal Account.—The interest and sinking fund is not included in the sewage disposal account. We have no difficulty in treating the trade effluents on the farm.

Private Streets.—The cost for making up private streets referred to is 1*l.* per lineal yard of street (i. e. 10*s.* per yard for frontage on each side). No rebates are made beyond the amount contributed by the Council, as previously mentioned.

I am of the same opinion as Mr. Wike as to the legality of enforcing duplicate sewers in private streets.

Underbedding.—All the underbedding required for making up the above-named streets is obtained free. Team labour only is provided, which accounts for the streets costing so little.

In reply to Mr. EAYRS:

The actual water supply per head per day, where charge is based on rateable value, is $8\frac{1}{3}$ gallons, exclusive of that used for manufacturing purposes. Where the supply for domestic use and where no w.cs. are provided is charged for by meter, the average is 2·86 gallons, and where w.cs. are used in connection with the latter the average is 6 gallons per head per day.

In reply to Mr. GREATOREX:

The questions referring to the under-drains, gas undertaking and electric lighting are answered in my reply to Mr. Price. As to charge for water for flushing sewers and street watering, I estimate that to cost us 120*l.* per annum.

As to Sewage and Storm Water.—In consequence of there being only one set of drains provided to the several properties, a large quantity of storm water from the roofs, yards and paved areas passes to the farm along with the sewage.

In reply to Mr. PLATT:

With respect to the birth and death rates, the particulars are based on the census returns. The cost of reducing the hardness of the water to 9° hardness varies from 1*d.* to $1\frac{5}{8}d.$ per 1000 gallons. The hardness of the water varies considerably.

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In reply to Mr. LYNAM:

As to Private Streets.—These are made up in the following manner, viz.:—

SWADLINCOTE DISTRICT URBAN DISTRICT COUNCIL.

PRIVATE STREET WORKS ACT, 1892.

SWADLINCOTE DISTRICT URBAN DISTRICT.

Surveyor's Specification of Private Street Works

in _____

Whereas the Urban District Council for the Swadlincote District, being the Urban Sanitary Authority for the said District, in the County of Derby, have in pursuance of section six of the Private Street Works Act, 1892, resolved to execute certain private street works in the said street known as _____

I, _____, the Surveyor to the said Council, Hereby Certify that for the purpose of carrying out the aforesaid Resolution, the works hereinafter mentioned will require to be executed in the manner set forth and of the materials described in the Specification following, that is to say:—to lay out, form, sewer, level, pave, metal, asphalte, channel, and make up the said street, forming carriageway with a footway on either side thereof, also provide proper means of lighting, in accordance with this Specification and Plans, now deposited in the Surveyor's Office, Swadlincote.

Sewers (A).—The Sewers to be constructed with sanitary pipes, jointed with clay, to the depths, of the sizes and forms, and at the rate or rates of inclination shown on the Plans and Sections of the works, as prepared by the Surveyor of the said Urban Sanitary Authority.

Gulleys (B).—Each gulley for surface draining and its connection with the sewer to be placed as shown on the said plans, or as directed by the Surveyor, and to be constructed of the form, materials and dimensions, as shown on the said plans.

Foundation of Carriageway and Footway.—The soil and clay to be excavated, where required, to an uniform depth of 12 inches, or such other depth as may be necessary over the whole surface of Carriage and Footways. The foundation of the Carriageway to be made with good clean potsherds and broken sanitary pipes, engine clinkers, etc., being in the centre about

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15 inches deep, well constructed and consolidated by the Steam Road Roller, as per Section.

Levelling.—Any low portions of the streets to be filled in with potsherds, engine clinkers, etc., as directed by the Surveyor. The Carriageway to be made in a convex form, each side being as near on a level as possible. The centre of road being in all cases at least two inches higher than the channels adjoining.

Carriageway to be metalled, paved, etc.—Carriageway to be metalled not less than 3 inches thick with best Bardon Hill (or other of equal quality) granite broken to pass through a two-inch ring. The whole surface being coated with a layer of suitable binding material, watered and consolidated by the Steam Road Roller. The crossings were shown on plans to be paved with 4 by 4 by 4 inch granite setts, upon a Lias lime foundation, bedded in sand and grouted in with liquid Lias lime.

Footways.—The Footpaths to be well formed with potsherds and engine ashes, and coated with well-made Asphalte a thickness of 2 inches when rolled and consolidated.

Channelling.—The Channelling to be 18 inches wide and formed with Tar Macadam 3 inches thick, upon an underbed of broken sherds as per Carriageway, and shall drop 3 inches below the top edge of the kerb stones, and shall be constructed with a slight regular fall to take off the surface water.

Kerbing.—To be formed of 4-inch by 9-inch Granite Kerbs from Bardon Hill Quarries, bedded in fine ashes or sand well and truly fixed to proper lines; the sides well pounded and left complete as per drawings.

Lighting (C).—The lamp columns, lanterns and other fittings necessary for providing proper means of lighting, to be similar in all respects as those used by the District Urban District Council.

Incidental Work.

(*Note.*—All costs and charges incurred in carrying out items marked A, B, C, are borne by the Council.)

The whole of the above-mentioned works to be executed in a good, workmanlike and substantial manner under my supervision and control [and in accordance with the plans and sections, copies of which are hereunto annexed].

_____ *Surveyor.*

The question referring to the water supply is answered in my reply to Mr. Eayrs.

On the conclusion of the discussion the Members walked to the works of Messrs. James Woodward, Limited, where they were afforded an opportunity of seeing the processes of manufacture of sanitary pipes, glazed bricks, and other goods. The next visit was to the works of Messrs. Thomas Wragg and Son, where the processes of manufacture of 6-*inch*, 9-*inch*, 18-*inch and* 24-*inch sanitary pipes were witnessed from the taking of the clay from*

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the pit to the completion of the finished article. Following the inspection of the works the Members drove to Bretby Park, the residence of the Earl of Carnarvon, where they were entertained at luncheon by Messrs. James Woodward, Limited, and Messrs. Thomas Wragg and Son, Limited. Alderman Wragg presided, supported by the President (Mr. E. G. Mawbey).

The remainder of the day was occupied by a visit to the Milton Water-works, where the Members inspected the Archbut-Deely process of softening water.

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DISTRICT MEETING AT SOUTHEND.

September 28, 1901.

Held at the Council Chamber, Southend-on-Sea.

E. GEO. MAWBEY, M. INST. C.E., PRESIDENT, *in the Chair.*

THE Members assembled in the Council Chamber, where they were received by the Mayor of Southend and his colleagues of the Town Council.

The Mayor offered the Members a most sincere and hearty welcome. Although not a town so large as many of those represented that day, they claimed and could give evidence by the plans around the Council Chamber that they had carried out works of interest not only to themselves but to the general community.

The President, on behalf of the Association, warmly thanked the Mayor and Corporation for their very kind welcome.

Mr. R. J. Thomas was unanimously re-elected as Honorary Secretary for the Home Counties District.

THE MUNICIPAL WORKS OF SOUTHEND-ON-SEA.

BY ALFRED FIDLER, ASSOC. M. INST. C.E.,
BOROUGH ENGINEER AND SURVEYOR.

THE Author has great pleasure in presenting to the Members a short paper descriptive of the Municipal Works of Southend-on-Sea.

The history of Southend shows that in the early part

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of the nineteenth century it began to be known as a sea-side resort. The Royal Terrace was built—a portion being occupied occasionally by members of the Royal family. After the London, Tilbury and Southend Railway was made the town began to grow until in 1891 the population was about 12,000 and the rateable value 70,000*l.*

It is situated on the north or Essex side of the Thames estuary, about four miles from its mouth. It was incorporated in 1892 and comprised the parish of Prittlewell. In 1897 the adjacent parish of Southchurch was incorporated with the borough.

The area of the borough is now 5172 acres.

The rateable value of the borough is now 200,000*l.*

The population at the last census, 28,793.

Thus in a decade the rateable value has been more than doubled—a rate of increase that can only be regarded as sensational.

It might be mentioned briefly that Southend undoubtedly owes its prosperity to its proximity to London. It is the nearest watering place to the Metropolis. It is admirably served for means of communication by three railway companies, and in the summer-time by numerous steamers.

In a town of such abnormal growth one can readily see that public works of infinite variety must keep pace with growing and increasing requirements.

The population is largely residential, numbers of the residents being engaged in business in London, and going to and from there every day. There is no staple trade or industry, unless the building trade can be so described. Naturally, owing to the large number of houses being built, a large number of men are employed. There are several brickfields in the neighbourhood. During the season the floating population reaches a high figure, very frequently 80,000.

There are 21½ miles of roads and streets, and about 11 miles of main roads in the borough. Besides the above there are many miles of roads laid out by private estate owners not yet taken over by the corporation.

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New Buildings.

The buildings bye-laws in force are based on the model bye-laws of the Local Government Board. Three building inspectors are engaged in supervising the erection of new buildings. The drains are all laid on concrete with water-tight joints and disconnected from the sewer. They are all water-tested before being covered up, and finally smoke-tested prior to the granting of the certificate for habitation which must be obtained before occupation of each house. A record book is kept which shows the history of each house inspected. The majority of houses built are of an annual rental of 35*l.* to 40*l.*, very few houses of the cottage class are erected. Recently some very ambitious buildings have been added to the town, large hotels, amongst them the unfinished Hotel Métropole, said to cost 300,000*l.*, and the Kursaal, said to cost 200,000*l.* The latter provides accommodation for dancing, a circus, theatre, and the other usual attractions peculiar to similar undertakings.

The number of new buildings certified as fit for habitation during the last four years is as follows: 1897, 352; 1898, 472; 1899, 586; 1900, 571.

New Roads and Streets.

The Private Streets Works Act, 1892, has been adopted. As soon as any new road or street is sufficiently built upon, which very quickly follows its laying out, steps are taken to make it up in accordance with the above Act.

The general construction of roadways:—9 inches hardcore and 6 inches flints; after steam rolling, granite kerbs and channels on concrete, footpaths paved with artificial slab pavement. The value of work executed in this department averages 10,000*l.* per annum. Payment is optional either within one month after service of apportionment notice or in four half-yearly instalments with 5 per cent. interest added.

Main Sewerage System.

Prior to 1897 the main drainage outfall system was of a very primitive character. Sewage was discharged at many points and at all stages of the tide. The natural result was a foul foreshore with its attendant evils.

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The present outfall system was designed and carried out by Mr. Mansergh, President, Institution of Civil Engineers, in 1897.

The works consist of two systems, viz. :—

(1) The Eastern Valley system.

(2) The Western Valley system.

In each a high level intercepting sewer discharges into a storage tank. There is also in each a low-level area from which the sewage is lifted to the storage tank. Each storage tank communicates with the main outfall which discharges into a channel just covered at L.W.O.S.T., about one mile from the shore and about 600 yards east of the pier. The sewage is discharged only on a falling tide, i.e. at high water to within two hours of low water. The outfall is 27 inches in diameter, laid at a ruling gradient of one in 1500, and is capable of discharging on an average 900 cubic feet per minute. Complete records are kept of the daily working and inspection of the foreshore, and it has been demonstrated that if the proper conditions are observed there is no deposit of sewage whatever on the foreshore, it is completely carried away to sea.

The capacity of the Eastern Valley storage tank is 540,000 gallons. The tank is covered and is constructed similar to an ordinary covered storage water reservoir. The normal daily dry weather flow into the tank averages 400,000 gallons.

The pumping plant at the Eastern Valley pumping station consists of three gas engines and pumps of the following sizes :—

(1) Gas engine and set of three-throw pumps capable of raising 169 cubic feet of sewage per minute, through 350 lineal yards of 15-inch diameter rising main, to a height of 26 feet.

(2) Gas engine and set of three-throw pumps capable of raising 31·5 cubic feet of sewage per minute, through 350 lineal yards of 15-inch diameter rising main, to a height of 26 feet.

The gas engines were made by Messrs. Crossley, Manchester, and the pumps by Messrs. Prachett, Carlisle.

The capacity of the Western Valley storage tank is 225,000 gallons. The tank is about 36 feet below ground level, and consists of two brick barrels 12 feet in diameter, communicating with each other. The normal daily dry weather flow into the tank averages 200,000 gallons.

The pumping plant at the Western Valley pumping station

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consists of three gas engines and pumps of the following sizes:—

(1) Gas engine and set of three-throw pumps capable of raising 126 cubic feet of sewage per minute, through 280 lineal yards of 12-inch diameter rising main, to a height of 41 feet.

(2) Two gas engines and two sets of three-throw pumps capable of raising 31·5 cubic feet of sewage per minute, through 280 lineal yards of 12-inch diameter rising main, to a height of 41 feet.

The gas engines were made by Messrs. Pollock, Whyte and Waddell, of Johnstone, N.B., and the pumps by Messrs. Prachett, of Carlisle.

The scheme was designed to deal with a population of 40,000 people, with an estimated dry weather flow of 800,000 gallons per day. The present population is rapidly approaching the above figure, and in view of the expected requirements, the Author has already received instructions to report on the whole question so that provision may be made in time, and that prospective requirements may be anticipated.

Main Drainage, Northern and Western Districts of Borough.

Besides extensions to the existing sewerage system, which the rapid growth of the town demands, there are several detached portions of the town which have required separate treatment. About one mile and a quarter north of the sea front, is situate the village of Prittlewell, which was only partially sewered by an old sewer running along a ridge and capable of draining only a limited area on either side of it.

Building operations to the north of this have been carried on despite the absence of sewers, and cesspools with their attendant objections have been introduced. In 1899 the Author was instructed to report on the subject.

He recommended the extension of the Sutton Road sewer as far as possible, the re-construction of East Street sewer, these two sewers forming the gravitating system, and the drainage of the low level area by a sewer discharging at a point near Prittlewell Priory (proposed pumping station), from thence to be pumped into the aforesaid Sutton Road main sewer. The

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low level sewer would be laid along a line and at such depths as would provide for the portion of the borough lying west of the present low level drainage area.

The report was adopted, and application made to the Local Government Board for sanction to borrow the sum of 15,500*l.*, the estimated cost of the scheme. Sanction was given for the gravitating or high level sewers pending arrangements with landowners for sites and easements for the low level portion. The first part of the work is partially completed, and the necessary provisional agreements having been made for land the remainder of the work will be put in hand.

The western end of the borough has been growing in a similar, though lesser, manner to Prittlewell. Provision has to be made for this by the construction of a low level sewer discharging into the Western Valley low level system.

Ventilation of Sewers.

Up to two years ago, the ventilation of sewers depended upon surface gratings. It is reported that an old authority when appealed to for a remedy said "Put another grating in between two existing ones." That policy pursued *ad infinitum* would result in a reversion to the old system of an open sewer. The Author reporting on the subject in 1898, recommended that a ventilating shaft or column should be fixed opposite every manhole, and the manhole cover sealed. The recommendations were adopted, and a loan for 3500*l.* obtained by sanction from the Local Government Board.

Where possible ventilating shafts (glass lined internally) 6 inches by 4 inches internal dimensions, are fixed against the sides of the houses, and in the highest parts. Where permission to fix these cannot be obtained, columns are erected on the footpath, 6 inches internal diameter and 30 feet in height.

The cost of erecting a shaft alongside a house complete is about 9*l.*, and of a column about 17*l.* The cost varies with the distance of the point of erection from the manhole. In the days of surface gratings complaints of foul smells from the sewers were constant. Now they are never received. This is a very satisfactory state of affairs.

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Pier.

Southend enjoys the reputation of possessing the longest pier in the country—1⅓ miles long. The estuary of the Thames here is very flat, and low-water mark is about one mile from the shore.

From the designs of the late Mr. Brunlees, the present pier was built in 1890, and cost 87,600*l.* It is built on cast-iron screw piles in rows of three, 30 feet apart, cross braced together; the decking is supported by wrought-iron plate girders, with rolled steel joists laid across, to which is secured the deck. There is an electric tramway single line, 3 feet 6 inch gauge, with a middle rail conductor. In 1898 the Author constructed a passing place and pier-widening midway down the pier, the nature of construction being practically similar to the present pier. The cost of the addition was about 3000*l.*, and since its completion the tramway has almost doubled its carrying capacity.

Additional waiting and refreshment rooms were also erected at the same time at the pier head.

The pier was extended, in 1896–7, 170 yards, by Mr. Brunlees, junr., and Sir J. W. Barry. There is now at the pier head about 30 feet of water at L.W.O.S.T., enabling very large steamers to land and embark passengers.

At the shore end of the pier there is a spacious pavilion 140 feet by 75 feet.

The current for the pier tramway and electric lighting is generated on the pier premises, but it is intended to obtain power from the central electricity generating station, and abolish the present station. It is estimated that this will result in a saving of 500*l.* per annum.

The pier undertaking has altogether cost 103,000*l.*, and since its completion has contributed over 15,000*l.* to the rates.

On August Bank Holiday, 1901, over 46,000 persons used the pier, and over 17,000 were carried on the tramway. For the twelve months ending March 1901 the respective figures were 815,000 and 622,000. The net profit for year ending March 1901 was 3623*l.*

One disadvantage of possessing such a long pier is that it offers such a large area of attack: several serious accidents have taken place through vessels being blown into it. The

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cast-iron piles, not being able to stand a side blow, snap like carrots, bringing the superstructure down with them. An accident two years ago cost the Corporation over 1000*l.* to repair the damage.

Cemetery.

Although there existed a cemetery in the town, it belonged to a Burial Board who had the power of making preferential charges on extra-parishioners. In 1897 the Council decided to establish a borough cemetery on land purchased for that purpose in Sutton Road in the north part of the borough.

The Author prepared plans for the erection of a cemetery chapel, lodge entrance, boundary walls, roads laying out, and planting.

These been carried out at a cost of 5500*l.*

The chapel is Gothic in character, built of Kentish rag stone with Bath stone dressings. It is 40 feet by 45 feet, will seat 60 persons, has wood block floor, pitch-pine seats and dado. There are a vestry and mortuary chapel attached.

The entrance lodge contains an office and house for curator. In this building and the boundary wall the same kind of materials were used as for the chapel.

Stores Yard and Depôt.

A stores yard and depot has been put into operation within the last twelve months.

The Author prepared plans, etc. for the work, which has cost for buildings, horses, carts, land, etc. upwards of 12,000*l.*

The buildings comprise :—

Offices for storekeeper, foreman and pay clerk, houses for horsekeeper and storekeeper, stables for 24 horses, hay lofts, harness rooms, provender rooms, etc., wheelwrights' shop, smithy, men's day room, cement store, sick horse boxes, cart sheds, steam roller shed, weighbridge.

The Corporation execute all the dust-collection, street-watering and scavenging, sewer flushing, and all the regular cartage work ; hiring being required for carting materials from loading pier or railway stations, constructional works executed by Corporation, etc.

The dust collected is delivered to the brickfields, where it is burnt in a crude kind of destructor.

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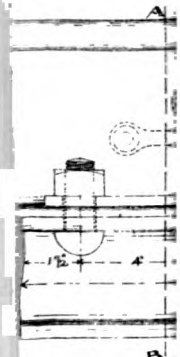

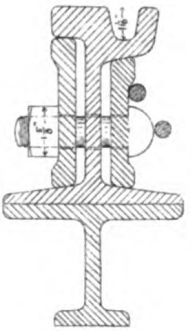

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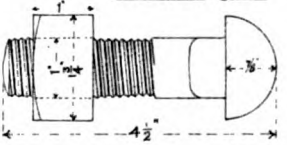
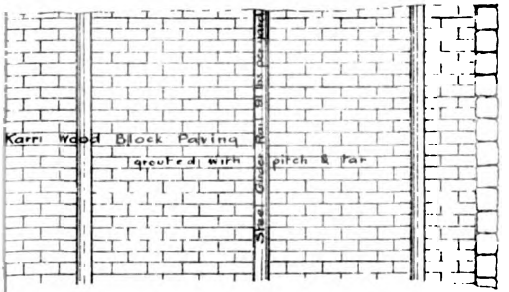
SECTION C.D.

FISHBLATT BOLT

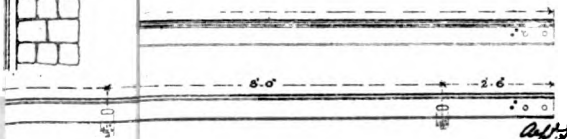


DOUBLE LINE — WOOD BLOCK PAVING

SECTION



PLAN



A/ Engineer for Roads.
Boro. Engineer

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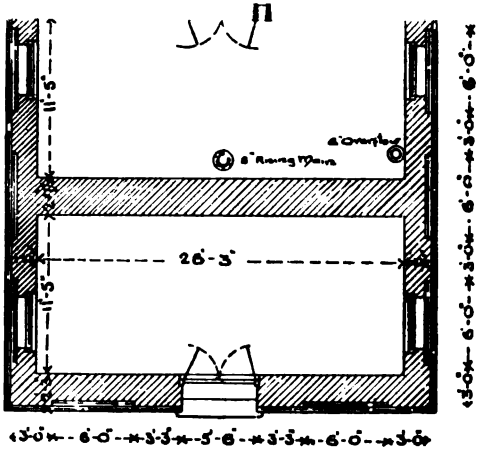
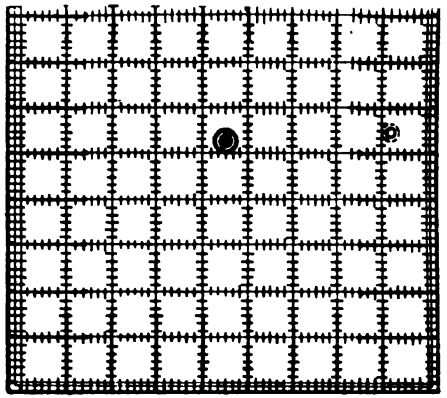


Ground plan.



Tank plan

SOUTHEND-ON-SEA: THE SEA-WATER STORAGE TANK AND TOWER.

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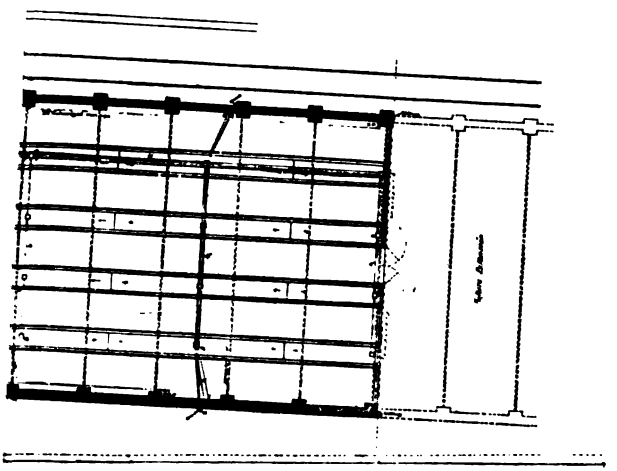

ED, &c., LONDON ROAD.

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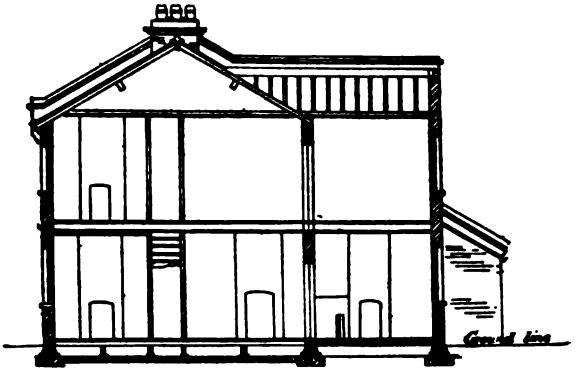

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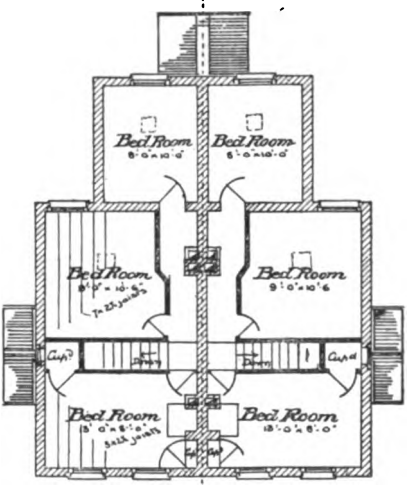

FIRST FLOOR PLAN.

ORKING CLASSES. CLASS A.

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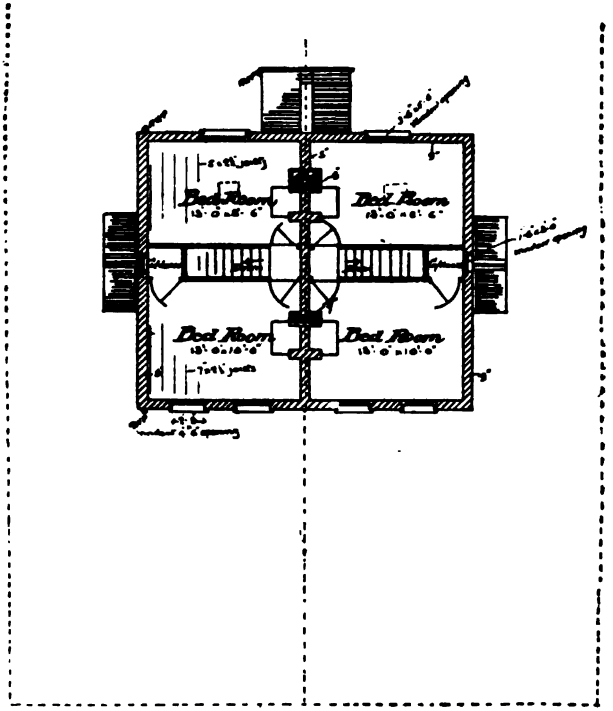

FIRST FLOOR PLAN.

·ON-SEA:

CLASSES. CLASS B.

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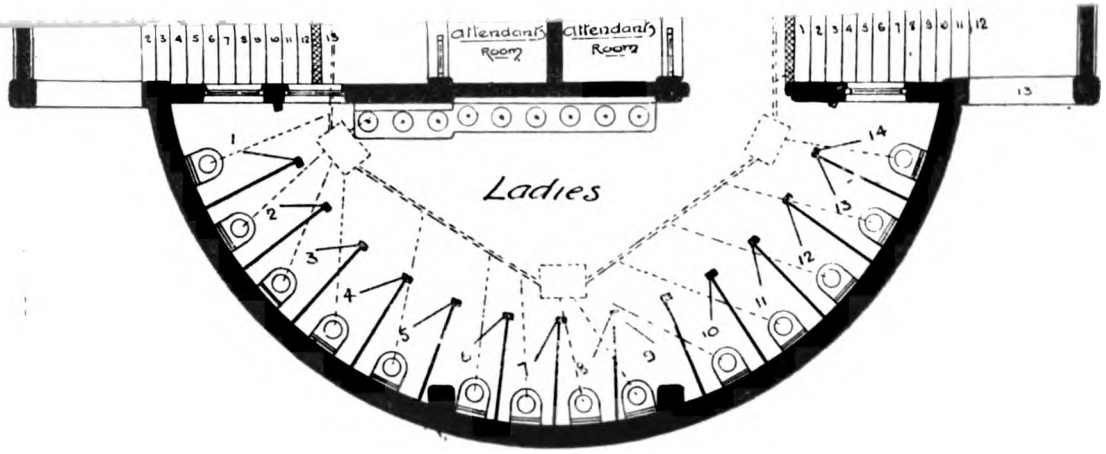

Plan.

p. 48—vi.

SOUTHEND-ON-SEA: UNDERGROUND CONVENIENCE, MARINE PARADE.

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The Corporation intend proceeding with the erection of a dust destructor, the Author having received instructions to prepare plans in accordance with his report submitted by him in 1899 and adopted by the Council.

Where possible, all materials are purchased by contract for a twelve months period. The manufactured materials required for contract work are invariably supplied from the stores depôt, where they have been thoroughly examined before acceptance. This saves time, and is the means of ensuring that good sound materials are used.

Southchurch Recreation Ground.

In 1897 the Corporation had conveyed to them about 20 acres of low-lying ground in Southchurch for the purposes of a recreation ground. Among the conditions attached to the gift were the construction of a lake for the drainage of the remainder of the estate, and a conduit to convey surplus water to the sea.

The Author prepared plans for the fencing, laying out and planting of the ground, formation of cricket pitches, construction of roads, lake, conduit, groyne, overflow and valve chamber. The estimated cost of the whole was 11,500*l.*

Of the above works the following have been carried out at a cost of about 5000*l.*:—fencing, cricket pitches, planting, lake, conduit, overflow and valve chambers, groyne.

The lake is three acres in area, 3 feet deep, top-water level 6·00 above O.D. or 4·5 feet below H.W.O.S.T. The conduit is a 24-inch diameter cast-iron pipe laid at a gradient of 1 in 417, and having a maximum discharging capacity of 613 cubic feet per minute. In order to allow for the discharge of flood-water from the lake when the height of the tide permits, a floating arm similar to the arrangement used for drawing-off supernatant water from precipitating tanks has been provided. By-pass valves are provided in case they should be required to supply sea-water to the lake. The lake can be emptied into the sea when required by means of an outlet-pipe and valve laid at the level of the lake bed. The arrangement has very quickly proved its efficiency.

In the winter of 1899 a sudden thaw accompanied by some days of heavy rainfall flooded all the neighbouring watercourses and land. In less than 48 hours the flooded area was completely

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drained. When the recreation ground is completed it should form a very valuable place of amusement for the residents of the eastern part of the town.

Southchurch Beach and Sea Wall.

One of the works covenanted to be done by the Corporation, on the incorporation of Southchurch with the borough, in 1897, was the making up of a portion of this road about half a mile in length. The manner and extent of such making up was not then determined.

In 1898 the Corporation decided to make the road 60 feet in width so as to form part of a comprehensive scheme for a continuous marine parade.

The work consists of a 60-feet road having a carriage-way 30 feet wide, footpaths 10 feet and 16 feet wide, and a sea wall. Sufficient land for this purpose was given by the owners of the foreshore opposite on condition that the beach south of the wall should be excavated and deposited in front of the wall. This involved filling up the voids with other material—not a very satisfactory condition to have to face. The filling was very carefully watered, rammed and consolidated. The road is supported by a slope seawards, 3 to 1, faced with basalt columnar blocks 6 to 9 inches deep, the joints filled with fine concrete.

Owing to the extraordinary tides of November 1897, the Local Government Board insisted on a parapet wall being built to a height of 1 foot 6 inches above the flood level or 7 feet 6 inches above H.W.O.S.T. and 18 feet above O.D. As the adjacent ground is only about 7·00 above O.D. this precaution is quite necessary. The construction of the road involved the purchase of forecourts of some of the houses. A claim made for interference to business was made and referred to arbitration. The award was against the Corporation, viz. 75*l.* and costs as against 250*l.* claimed.

The work carried out is a very good object lesson of public improvements adding to the value of abutting property. In this case a moderate estimate would be 30 per cent. increase. At present the road is one of the finest in the town, fronting on to a part of a sheltered bay provided with an excellent beach. At no distant date this road will be extended along the sea shore to Shoeburyness, and with it will follow as a matter of course electric tramways.

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Sea Water Scheme.

The water supply is in the hands of the Southend Waterworks Company who obtain water from wells in the town and neighbourhood. The wells are all sunk into the chalk, the yield varying from each. The difficulties of keeping pace with the growing demands have been experienced by the waterworks company, and despite continuous extensions their resources are taxed to the utmost in a dry summer.

One feature of the maximum demand has been the reduction of the supply for street watering and sanitary purposes. In a health resort one naturally looks for clean streets, well watered, and free from dust. To ensure this a constant water supply is necessary.

In 1899 the Author reported on the question of the utilisation of sea water for street watering and sanitary purposes.

In his report the following reasons were given for the use of sea water, supported by figures showing an immediate saving by the substitution for fresh water.

Sea water is about twice as effective as fresh water for street watering purposes. The surface of the road is solidified, and the maintenance reduced. Sea water possesses hygrometric properties, dust is kept down by the adhesive character of salt-water for a longer period. Owing to its greater efficiency for road watering purposes less water will be required, and a further saving effected in distribution. As a flushing agent it is more valuable owing to its greater specific gravity. It reduces the generation and accumulation of sewer gas, and by being able to use it in large quantities deposits in sewers can be prevented.

Water was supplied by the water-works company at 1*s.* per 1000 gallons. The annual amount paid to the company for water and meter rents was nearly 700*l.* After paying interest and sinking fund on the cost of the works plus working expenses it was estimated that there would be a profit on the scheme, besides which, with cheaper water there exists a strong inducement to make a more lavish use of it. As the town increased the annual saving would be greater, the proposed works being capable of yielding a supply of ten times the present consumption without any additional capital outlay. The report was adopted. The Local Government Board sanctioned a loan for the execution of the works.

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The works consist of: Underground pumping station; rising and distributing mains, street watering pillars, etc.; water tower; pumping station and pumps.

The pumping station is underground, opposite the loading pier in Marine Parade. It is 20 feet by 17 feet by 10 feet 6 inches high. The floor and walls are of concrete, and the latter faced with white glazed bricks set in cement mortar. The ground being saturated at high water to within four feet of the surface the whole of the walls and floor are coated with a layer of asphalt 1 inch thick, put on in two layers. The roof is formed of rolled steel joists filled in with concrete finished with Val de Travers asphalt 1 inch thick. Hayward's lights are let into the roof to provide light into the interior. Access is gained by a flight of stone steps. The chamber is drained by a pipe discharging on to the beach governed by a sluice valve inside.

Advantage has been taken by the Corporation, being the proprietors of the electricity works, to add to its list of customers. It was decided to drive the pumps by electricity.

The requirements were to raise 25,000 gallons of sea water per hour to a height of 160 feet, through 1¼ mile of rising main 8 inches in diameter.

Pumps and Motor.

The pumps are of the double-acting three-throw ram type, 6¾-inch barrel and 12-inch stroke. The pump barrels are of cast iron, brass lined and mounted on a cast-iron base bolted to bed plate. The valve chambers are in one casting, with covers fitted for giving easy access to valves. The pump rods are of delta metal, fitted at bottom end to brass buckets having brass spring rings, and at top to cast-iron crossheads. The cranked shaft is of best forged steel, having three double cranks shrunk on. This is supported on frames carried from pump barrels and geared to motor by two sets of spur gearing. The first motion pinion is of raw hide; the wheels are of cast iron with machine cut teeth; the second motion gear having double helical teeth.

The motor is inclosed and of 40 brake horse-power, running at 500 revolutions per minute, this being reduced by gearing to 50 revolutions per minute at the crank shaft.

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The cast-iron bed plate to carry motor and pumps is of heavy section, fitted to concrete foundation and bolted down with steel foundation bolts and cast-iron washers.

Rising and Distributing Mains.

All the pipes are cast-iron socketed pipes, all tested to a head of water 600 feet high, coated with Dr. Angus Smith's preparation while hot, and jointed with yarn and run and caulked with best blue lead.

The pipes were manufactured by the Société Métallurgique d'Aubrieves, Aubrieves, France.

The pipes are of the following thicknesses and weights. 9 feet 10 inch lengths (exclusive of sockets):—

Size of pipe in inches	8	6	4	3
Thickness in inches	½	7/16	⅜	⅜
Weight, inclusive of socket, in lbs. per yard ..	161	82	55	37

The pipes were laid with a minimum covering of 3 feet. In many cases, owing to the depths of existing pipes, this covering was greatly increased.

The rising main is 8 inches in diameter. It is also a distributing main, supplying all the branch mains, the surplus water thus passing into the storage tank. The distributing mains vary in size from 6 inches to 3 inches. Connections are made to the various mains for supplies to street watering pillars, flushing chambers, lavatories, etc. The total length of the rising and distributing mains is 10½ miles.

Each section is governed by a sluice valve in order that repairs can take place without the whole system being thrown out of operation. Air valves are placed at all high points. Street watering pillars are placed about 300 yards apart, each governed by a sluice valve and fitted with a frost cock.

The distributing mains are laid in various streets and roads, embracing a district 2 miles long and 1½ miles broad. The mains traverse both county and borough roads, the county authorities being our customers for water.

A telephone wire (lead sheathed) has been laid in the 8-inch trench between the pumping station and water tower, with branch to the Borough Engineer's office.

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Water Tower and Tank.

The water tower is situated in the stores depôt. It is a brick structure, 44 feet high from ground level to top of brickwork, and 55 feet to top of tank. The foundation rests on hard clay, and consists of a bed of Portland cement concrete 6 to 1 3 feet thick, carrying a 3 feet thickness of blue brick footings set in cement mortar 2 to 1. The walls of the tower are built with Fletton bricks, with red brick arches, and York stone sills and dressings. The walls are 2 feet 7½ inches thick at the base, and 18 inches at the top.

The distributed weight when the tank is full is 1⅔ tons per super foot on the clay foundation, 1·75 tons per super foot on top of the concrete bed, 3¾ tons per super foot on the top of the brick footings, 4 tons per super foot on top of the brick walls.

The roof of the tank is formed with rolled steel joists spaced 12 inches apart, resting on the external and cross walls and filled in solid with Portland cement concrete 6 to 1. Galvanised iron sheets are placed between the girders, forming centres for concrete filling and remaining as a permanent finish.

The brick tower is surmounted by a cast-iron tank 30 feet 6 inches by 30 feet 6 inches by 10 feet 9 inches, with a capacity of 60,000 gallons.

The floor and lower side plates are 3 feet 3 inches square and 1 inch thick; the second row of side plates are 3 feet 3 inches square and ⅞ inch thick; the third row of side plates ¾ inch thick, and top plates ⅝ inch thick. All plates are flanged on the inside, stiffened with brackets and bolted together with ¾ inch bolts, the joists are then tightly caulked with a mixture of sal-ammoniac and iron borings.

The tank is internally stayed with wrought-iron tie rods bolted to the floor, and bottom and middle side plates.

An electric water-level recorder is fixed in the water tank, an index placed in the generating station and pumping station automatically recording the amount of water in the tank and enabling the pump to be stopped at either end.

The total cost of the scheme was 10,900*l.*

The contractors for the whole scheme were Messrs. A. Penney & Co., London. The makers of the motor and pumps were Messrs. Bow, M'Lachlan & Co., Paisley; the valves and hydrants were made by Messrs. Ham, Baker & Co., London.

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Light Railways Scheme.

One of the most important schemes carried out by the Corporation is the Light Railways Scheme. They were quick to recognise the necessity of a regular and rapid means of locomotion for the large masses of people who congregate here during the season, to and from the sea front and the outskirts of the town.

In 1898 the matter was considered, and instructions given to the Author and the Electrical Engineer, Mr. J. B. Mitchell, A.I.E.E., to prepare reports upon a proposed scheme of tramways.

Electric traction was recommended, also the overhead trolley system. The scheme was not adopted in its entirety, the proposed routes along the sea front, High Street, Marine Parade, and to Shoeburyness, being struck out.

The Town Clerk advised that an attempt should be made to obtain powers under the Light Railways Act, 1896. The Corporation adopted a scheme for the construction of the following lines:—

Railway No. 1.—From the "Middleton," High Street, to the "Blue Boar," Victoria Avenue. Total length, 0 miles 6 furlongs 5·70 chains.

Railway No. 2.—From the "Blue Boar," Victoria Avenue, to the "Cricketers," London Road. Total length, 0 miles 5 furlongs 6·53 chains.

Railway No. 3.—From Leigh parish church to Southchurch parish church. Total length, 4 miles 0 furlongs 8·5 chains.

Railway No. 4.—From Southchurch Road, along Southchurch Avenue, to Marine Parade. Total length 0 miles 4 furlongs 2·80 chains.

All lines single lines, with all necessary passing places, curves, sidings, etc.

The gauge ultimately decided upon was 3 feet 6 inches, although the Author was strongly of opinion that it ought to have been 4 feet 8½ inches. The question of cost, however, was the deciding factor, coupled with the narrow widths of some of the roads. In all light railway schemes where possibilities exist of junction with railways the gauge should be the standard gauge.

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Other works included in the order to be an electricity generating station, electrical plant, cars, car-shed, etc.

Resolution passed for application to be made to the Light Railway Commissioners for powers. The Southend Corporation were the first corporation in the country to take advantage of the Light Railways Act.

It is a more advantageous method of procedure than obtaining Parliamentary powers, being more economical and expeditious; it does not invite opposition to the same extent, and the financial clauses are much less stringent. Deposits may be made twice a year—in November and May—the method being similar both as to preparation of plans, estimates, reference and notices.

The Author was instructed to prepare the necessary plans, estimates, books of reference, etc., and these and the order were deposited in November 1898. The inquiry by the Light Railway Commissioners was held in January 1899, by the Board of Trade in May, and the order confirmed by the latter in September of the same year.

The estimated cost of the whole scheme was 80,000*l.*, which included costs of application, purchase of land, and construction of works. On the whole, the cost of road-widening was very small, considering that about 60 per cent. of the routes ran along county roads, many of them being yet country roads. The main street in Leigh possessed a width between the kerbs varying from 24 to 18 feet. After some protracted negotiations it was agreed the road should be widened to a width between the kerbs of 24 feet, the Corporation to pay 650*l.* as a contribution towards the cost. On the remainder of the routes the roads had to be widened to a width of 23 feet between the kerbs, where roadside waste existed to be utilised for the purpose.

Various clauses were inserted in the order for the protection of the postal telegraphs, gas and water companies, railway companies, and the various road authorities.

Road Metal.—The order provides that the road metal removed from the site of the permanent way shall be removed to the store of the road authority. This appears unjust. It ought to become the property of the undertakers as they have to maintain a width of the road permanently, and the road material could be utilised in many cases for the concrete foundation.

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The period allowed for the construction of the works was three years. Should any portion of the works remain unfinished after the lapse of that time from the confirmation of the order the powers to lapse. The undertakers being also bound to use the lines continuously, failing which the same to be taken up and the roads restored at the cost of the undertakers. Penalties for non-observance of various requirements were also inserted. The loan period was for 50 years, charged on the General District Fund.

Although no application had been made by any company for powers to construct tramways before this, it was common knowledge that had the Corporation not gone for powers when they did, two companies intended making application at the same time, but recognising that they could not succeed without the support of the local governing body they wisely ceased their operations. In this age of municipal enterprise it certainly would have been a reflection on a progressive and growing town like this if the opportunity of obtaining the control of street tramways had been allowed to slip.

Although the powers had been speedily obtained, for some little time the Town Council were somewhat lethargic in putting them in operation, and it was not until the early part of 1900 that any energetic move was made.

In March, Mr. Mitchell, the borough electrical engineer, was appointed to a similar position at Plumstead, and the Author was asked to take over the electrical department. As a temporary expedient the Council agreed to allow him what electrical engineering assistance he should require.

Mr. D. F. Adamson, M.I.E.E., was appointed electrical engineering assistant, and the Corporation on taking over the works appointed him borough electrical engineer and tramways manager.

The Author was instructed to prepare detailed plans, specifications and quantities for the whole of the works comprised in the order, and in June 1900, tenders were invited for the following:—

(1) Permanent way.

(2) Steel rails and fishplates.

(3) Engine and boiler houses, car shed, workshops, offices, chimney shaft, etc.

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(4) Boilers, condensers, pumps, etc.
(5) Engines, generators, switchboards, crane, etc.
(6) Motors and car equipments.
(7) Cables.
(8) Overhead equipment.

Tenders for 14 car bodies had been received in February, and the order had been given to the Brush Electrical Engineering Company, Loughborough, to supply them.

The cars were 14 in number, and of the following capacities:—

10 single truck double deck cars, to carry 38 passengers.
2 single truck single deck cars, to carry 20 passengers.
2 double bogie double deck cars to carry 58 passengers.

The car bodies were to be delivered to the Corporation car sheds by April 1st, 1901. The prices paid were 235*l.*, 198*l.*, 315*l.* each respectively.

Description of Car Bodies.

Principal Dimensions.

	Single Truck.	Single Deck.	Bogie Cars.
	ft. in.	ft. in.	ft. in.
Length inside body	13 7	15 1	21 3½
Length over platform	24 2	23 2	32 4½
Width over all	6 4	6 4	6 4
Wheel base	5 6	5 6	14 0
	tons cwt.	tons cwt.	tons cwt.
Weight, exclusive of electrical gear	3 5	2 15	4 0

The bottom frames are of oak, steel for the bogie cars, pillars teak, panels floor 1-inch red deal with spruce wearing grids, roof-ribs hardwood, covered with 1-inch deal boards, doors and inside casings teak, ¼-inch plate-glass glazing, tapestry blinds on brass-cased tubes, seats and backs three-ply birch veneer with loose carpets, polished handrails, swing ventilators, illuminated route box and signal light, pedal gongs, platforms oak-framed, plated with ⅜-inch wrought iron, flooring of tongued and grooved red deal, collapsible gate fixed at each entrance, also hardwood steps, four sand boxes, street steel dash, staircase to each platform, with sheet steel springers and wood risers, all clear of controller and brake, bonnets continuation of roofs, top seat pitch pine slot and spaced, fixed transversely. Each car is fitted with ratched handles for brakes.

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The car bodies were delivered to the Corporation car shed, where they were mounted on the trucks and received the electrical equipment.

Tenders for the eight sections of the work were received in July 1900. Ultimately the tender of Messrs. Dutilh, Smith, M'Millan and Co., London, was accepted for the whole of the work for the sum of 87,500*l.*

The great rise in the price of metals and other materials and labour had thus caused the estimates made in 1898 to be exceeded by about 20 per cent.; the total cost of the works, including car bodies, being nearly 91,000*l.* About 13,000*l.* of this expenditure was allocated to the electric lighting account, it being intended to generate current at the central station for both traction and lighting purposes. In subsequent borrowing powers obtained from the Local Government Board this sum was included, so that the whole of the expenditure on the scheme was fully authorised.

The time fixed for the completion of the whole of the works was 1st May, 1901. The detailed plans and specifications were approved by the Board of Trade and the outside road authorities, and everything was in order for a speedy prosecution of the work, but on some of the sections, owing to various reasons, there were considerable delays, which prevented completion by the specified time.

Rails and Fishplates.

The rails were made in 45-feet lengths. Depth of rail $6\frac{1}{2}$ inches, width of flange 6 inches, tread $1\frac{7}{8}$ inch, groove $1\frac{1}{16}$ inch wide by $1\frac{1}{16}$ inch deep, guard $\frac{5}{8}$ inch wide. For curved rails the guard is $\frac{7}{8}$ inch thick, and the groove $1\frac{1}{4}$ inch wide.

The centre of the web is arranged so that the centre of the load is directly on it.

The weight of straight rails is 91 lbs. per yard.

The weight of curved rails is 94 lbs. per yard.

The chemical composition of the steel of the rails was as follows:—

	Per cent.
Carbon	·45 to ·55
Phosphorus	·07
Sulphur	·05
Manganese	·8 to 1
Silicon	·1 to ·2

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The tensile stress of the steel was 37–42 tons per square inch, with an elongation of 20 per cent. in a length of 18 inches, and with a contraction of sectional area of 50 per cent. Also a 5-feet length of rail on supports 3 feet apart, to stand a drop test of one ton falling from a height of 20 feet without fracture.

The price of the rails delivered at Southend was 7*l.* 15*s.* per ton.

Fishplates.

The steel for the fishplates is softer than the rails, the chemical composition being as follows :—

	Per cent.
Carbon	·15 to ·20
Phosphorus	·10
Sulphur	·07
Manganese	·05

The fishplates are 1 foot 7 inches long and weigh 38 lbs. per pair.

The price for fishplates delivered in Southend was 12*l.* 18*s.* 7*d.* per ton.

Track.

The ground was excavated to a depth of 12 inches. The rails were then laid in line and gradient, and supported temporarily on wood blocks. At each rail joint an "Anchor" sole-plate of the inverted rail form was used bolted with eight bolts and imbedded in the concrete foundation. This will effectually prevent the damage to the way caused by the hammering of loose rail ends. The joints are then made and bolted together, after which the concrete foundation was placed in position and thoroughly packed under the rails, and brought up to an even and smooth surface for the paving. After the concrete was set the blocks were removed and the blocks securely packed with concrete.

The concrete was composed of 6 parts of Thames ballast to 1 part of Portland cement. The cement to stand a tensile strain of 375 lbs. per square inch, neat cement made into briquettes standing in air 24 hours and 144 hours in water. To leave no residue on a sieve of 40 meshes to the inch, and 10 per cent. residue on a sieve of 50 meshes to the square inch.

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The sides of the rails were parged with a mixture of 1 part of cement to 3 parts of sand. The paving was laid on a bed of fine sand 1 inch thick.

Tie Bars.—Tie bars were 2½ inches deep by ⅝ inch thick wrought iron, to stand a tensile strain of 21 tons per square inch. The ends have ⅞ inch thick threads, and nuts and washers on each side of the rail. The tie bars were spaced on an average 8 feet apart.

Bonding.—The rail joints were double bonded with "Neptune" solid copper bonds, ·166 square inch cross section, in one piece over the fishplates from rail to rail. The track was cross bonded every 40 yards single line, and 80 yards in double line. The conductivity of the copper was 98 per cent. The bond holes were carefully cleaned, and the nipples polished bright before insertion.

Paving.—In the initial stages of the consideration of the scheme the question of the nature of the material to be used for the pavement of the track was considered. Great objections were made to the use of granite on account of its noisy and slippery nature. The other extreme, wood, could not be entertained as the life of the margins would certainly have been very short. The wear on a track in the middle of a macadamised county road would have been unduly great, and except in cases where the whole width of the road could have been paved, wood paving would not have a fair chance.

When inquiries were made a material was found said to possess the qualities of silence and non-slipperiness—basaltic lava, used very largely in many Continental towns, and also in some English towns, some of the earlier ones to use it being Norwich, Nottingham and Plymouth.

The material was ultimately adopted. It is minutely cellular, exceedingly tough and fibrous, possesses no plane of cleavage, and emits a dull sound when struck with a hammer or a horse's hoof. From its nature it cannot possibly wear slippery.

The setts are not made in English style, oblong, but about 6 to 6½ inches and 6 inches deep, this greater width being permissible owing to the grip not being dependent on the joint. The covering capacity of these setts is about 5 yards per ton, and they showed a considerable saving over granite at about 5*s.* per yard, and over wood at about 8*s.* per yard.

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A total saving of 8000*l.* has been effected by using this material instead of granite. From economical motives the setts were not specially dressed on the surface, the Continental practice eventually proving that the surface wears down evenly. The local experience is that, although the irregularity of the newly paved surface is objectionable, it speedily improves under wear. Specially dressed setts cost about 1*s.* per yard extra, and in the opinion of the Author this expense is worth incurring to get the advantage of a more even and better looking pavement.

The setts are laid on a bed of sand 1 inch thick and grouted with a mixture of screened washed sand two parts, and one part of cement.

Wood Paving.—The track is paved with jarrah wood for a length of 260 yards. Eventually this length will be paved right across the road with the same material. Some trouble has arisen from expansion of the material, the blocks rising above the surface or forcing the points out of gauge. This is a very bad quality that wood possesses, and entails constant attention to correct the inclination to move outwards.

Where wood paving occurs the concrete foundation is floated to a smooth surface with cement mortar two to one.

Passing Places and Interlacing Lines.—The passing places are placed at average intervals of about one-fifth mile, the distance varying with special requirements. They are three chains in length overall, and can accommodate three cars on each road.

They are so arranged to have a straight run in on the facing sides, this necessitating the centre line of the road to be deviated from at each end for about 40 feet. At two points on the route where the distance between the kerbs is less than 23 feet double single lines were laid down, and arranged that the distance between the two inside rails should not exceed 2 feet 6 inches, so in no case could the lines be used as passing places, and the car traffic would proceed along its own side of the road. This, of course, calls forth complaint from the shopkeepers who have to move their carts from opposite their shops on the approach of the cars.

The crossings and points are all made from crucible cast steel, the tongues being forged steel. The crossings are made at an angle of 1 in 5, and are 4 feet 6 inches long with chequered tops. The standard points are 7 feet 6 inches long and are of

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the automatic spring and open or dummy type. Movable points are provided at all junctions and sidings. Cast-iron filling pieces are provided for the heels of the points.

Cost of One Mile of Track.—The cost of one mile of track, including providing all labour and materials, carting away road material, bonding rails, etc., is about 4775*l.* This sum is exclusive of the cost of any road-widenings necessary for the execution of the works.

Generating Station, Car Shed, Etc.

The generating station, car shed, etc., are built on land adjacent to the stores yard. The land was originally purchased for a stores yard and an electric lighting station, and in order to use a portion of it for the present purpose, which was other than the one for which the Local Government Board granted the loan, it had to be sold, and re-purchased out of moneys provided in the Light Railways Order.

The buildings consist of—

Engine house, 84 feet by 42 feet by 37 feet high to the eaves.

Boiler house, 84 feet by 48 feet by 32 feet high to the eaves.

Battery room, 35 feet by 32 feet by 13 feet high to the eaves.

Car shed, 180 feet by 47 feet by 24 feet high to the eaves.

Offices and workshops.

Chimney shaft, 150 feet high.

The buildings are of brick, stock brick facings relieved with red brick string courses and arches and stone dressings. The internal walls not plastered are faced with Fletton bricks. The roofs of the engine house, boiler house and car sheds are supported by steel principals and covered with Bangor slates, light being obtained in each case by bays glazed with Rendle's patent glazing. The floor of the engine house is concrete, finished with terrazzo paving, the boiler house paved with blue bricks, and the car shed cement rendered. Temporary ends have been left at the western end of the block for future extension. There is spare room in the engine house for two additional sets of generators, in the boiler house for two additional boilers, and the car shed will accommodate 30 cars. It contains four lines of rails, under each being a car pit, which saves unnecessary

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movement when examination of the trucks and motors is required.

All the rain-water is conducted to a tank under the floor of the car shed, which also receives the car washing water.

The water is pumped into an overhead tank for boiler feed and condensing purposes.

The chimney shaft is 150 feet high above the ground line. Measuring across the angles: at the base outside, 18 feet; at the top outside, 13 feet; at the base inside, 11 feet 6 inches; at the top inside 10 feet 3 inches. It is octagonal on plan. The bottom of the concrete foundation is 19 feet 6 inches below the ground line. It is 26 feet square and 7 feet 6 inches thick, composed of 6 parts of Thames ballast to 1 of cement.

The distributed weight on the clay foundation is 1½ tons per square foot. Upon the concrete foundation brick footings set in cement mortar are placed for a depth of 4 feet. The thickness of the brickwork of the shaft is 3 feet at the base, diminishing to a thickness of 14 inches at the top, by 4½ inches set off every 25 feet. A firebrick lining is carried up within the chimney to a height of 25 feet, and separated from the main wall by a cavity 2 inches wide. Two flue openings have been left in the chimney, one being left for future extensions. Two copper conductors have been fixed communicating with a copper band at the top with four terminals; the lower ends of the conductors are attached to earth plates buried in the ground.

The chimney was built from the inside, internal scaffolding being used. Skyers (Barnsley) bricks are used for facing, Fletton bricks being used for backing. The whole of the work in connection with the chimney occupied six months. The cost was 1250*l*. The chimney is much larger than for present requirements, but provision has been made for future extensions, and possibly a dust destructor.

Boilers, Condensers and Pumps.

There are three "Economic" boilers made by Messrs. Davey, Paxman & Co., Colchester. Each boiler is 14 feet by 8 feet, with two flues 2 feet 8 inches in diameter. Designed for a working pressure of 150 lb. and capable of evaporating 6000 lb. of water per hour from cold feed. The heating surface is 1180 square feet, and the grate area 31 square feet. The boilers are

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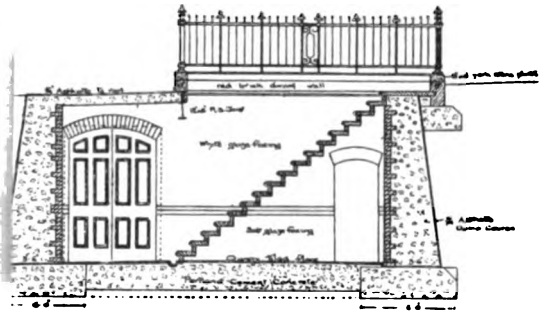

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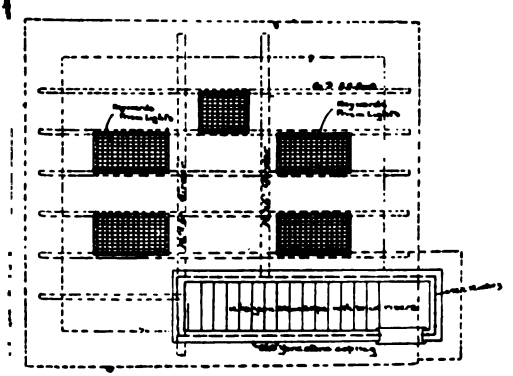

— Plan of Roof —

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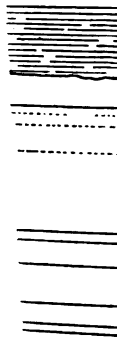

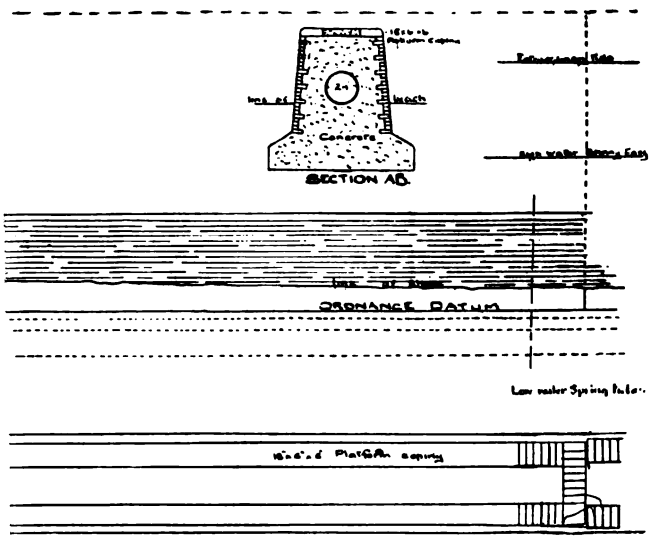

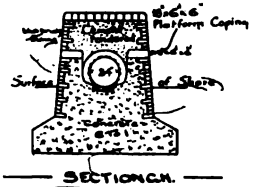

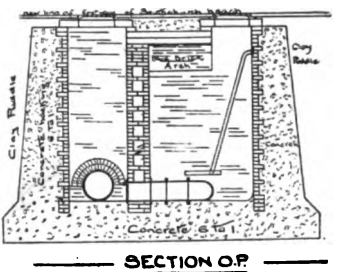

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fitted with water-gauges, water-level pointers, steam-pressure gauges, safety valves, steam stop valves, check feed valves and cocks and isolating valves. The boilers are Hopkinson's and Dewrance's.

The range of steam pipes is in duplicate, and is fitted with isolating valves, steam generators, separators, and traps. Steam recording pressure gauges are fitted to the electrical engineer's office and the engine room.

The condensing plant is of the Wheeler-volt type, combined heater and condenser. It is placed in the boiler house, but protected from dust by a glazed partition.

The pumping plant consists of two three-throw Blake-Knowles pumps each capable of dealing with 1250 gallons per hour, and two small centrifugal pumps for emptying sumps. All the pumps are electrically driven. Auxiliary feed-water tanks are placed over the battery room, also a Barnard cooling tower, the fans for which are driven by an 18 horse-power motor from the pump room.

The feed water is supplied from the water company's mains supplemented by roof water collected in underground tanks.

Steam Generators, Switchboard, Crane, etc.

The generators consist of two 200 kw. sets and one of 125 kw.

The large engines are of vertical Corliss type with cylinders 14¼ inches by 31 inches diameter and 24 inches stroke. They run at 110 revolutions per minute, and with a steam pressure of 150 lb. per square inch develop 322 I.H.P. A re-heater is placed between the high and low-pressure cylinders. A Tate's electric safety governor and stop motion and a Lamb's speed regulator are also fitted to these engines.

The six-pole generators coupled to these engines are each for an output of 200 kw., the terminal volts being 500–550, and the full load 364 amperes. The emergency load of this set is 300 kw.

The small set consists of compound inclosed engine, with cylinder 9½ inches and 21 inches diameter by 10 inches stroke, running at 360 revolutions per minute. This engine has a piston valve on high-pressure cylinder, and flat valve on low-

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pressure. It is equipped with forced lubrication, while the governor is of the fly-wheel type. The dynamo coupled to this engine has a normal output of 125 kw., and an emergency output of 200 kw.

The switchboard is of white marble, and measures 34 feet 8 inches long, consisting of 20 panels each 7 feet 6 inches high and 2 inches thick, and contains 7 lighting feeder panels, 4 generator panels, 1 Board of Trade panel, 4 traction feeder panels, 4 pumping station feeder panels.

All circuits are equipped with British Thomson-Houston circuit-breakers and quick-break switches, and British Thomson-Houston wattmeters are supplied on all generators and lighting feeder circuits, there being 18 wattmeters in all.

All ammeters and voltmeters are Weston illuminated dial, the main voltmeters being mounted on swinging brackets at either end of the board. The traction feeders are also equipped with the magnetic blow-out lightning arresters.

The engine room is fitted with a 20-ton overhead travelling crane running on Vignoles rails 42 lb. per yard, laid on stone kerb supported by corbelling from walls.

Trucks, Motors and Car Equipments.

The trucks are Brill–21 E type, with solid forged frame. The bogie-trucks are Brill Maximum traction trucks. The wheels are cast charcoal iron, and guaranteed for an average run of 30,000 car miles. The brakes are link suspended; there are two independent sets of springs, viz. the journal box cushion spring and the car-carrying spring.

The wheel base of the single trucks is 5 feet 6 inches, with 30-inch wheels. The wheel base of the bogie trucks is 4 feet, with 30-inch diameter driving wheels and 20-inch diameter trailer wheels.

Each car is fitted with two Thomson-Houston G.E. 60 railway motors, enclosed type. The efficiency through the gear is 85 per cent. The motors are capable of developing the rated load for one hour continuously with a rise of temperature not exceeding 70 degrees F. and an overload of 50 per cent. for short periods without undue heating or sparking.

The trolley is of the swivelling arm type, with inside springs. The head is insulated from the trolley arm by a

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woodite sleeve. The boom consists of a conical steel tube, 13 feet 6 inches long, tapering from 1½ inches diameter at the butt to 1 inch at the end, taped throughout its length. The standard is a cast-iron base, with steel tube fixed in and bolted down to the roof. The springs maintain a pressure of 18 lb. between the wheel and the trolley wire.

The controllers are B.T.H. series, parallel type, and arranged so that the motors may be converted into generators and used as emergency brakes or as regular brakes. The controllers are fitted with two handles, one for reversing the car and the other for the operation of the motors.

The cars are all electrically lighted inside, with head and tail lights and destination boards outside.

The truck and car equipments were fitted on to the car bodies at the Corporation car shed, where they had been delivered by the makers, the Brush Electrical Engineering Company.

Cables.

The cables were laid along the footpaths with about 2 feet 6 inches cover, on the solid system with Sykes stoneware ducts. The average working pressure will be 500 volts, and the cables were tested to 2000 volts. The conductors are of copper of high conductivity, and the cables are stranded and coated with tar.

Overhead Equipment.

The overhead equipment is arranged on the side pole system. It is divided into half-mile sections, each section fed at its ends through feeder pillar switches from the feeder pillar.

The poles are 31 feet in length, steel lap welded, in three sections telescoped into each other, provided with ornamental cast-iron base collars and finials. The poles were in three grades, the weights being A 990 lb., B 1321 lb., and C 1593 lb.

The bracket arms formed of 2 inch steel tubes ¼-inch thick, stiffened with tie rods and fitted with ornamental wrought-iron scroll. The poles are erected 40 yards apart, bedded 6 feet deep on 12 inches concrete, and an iron plate, pole surrounded by an envelope of concrete 9 inches thick.

Double trolley wires are fixed throughout, hard drawn copper of 000 B. and S. gauge, with a conductivity of 98 per cent. of

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Mathieson's standard of pure copper, with a breaking strain of 5000 lb., with an extension of not less than 5 per cent. on 8 inches. The section insulators are straight under running and adjustable, the line is insulated throughout.

The span and guy wire is galvanised steel 7-strand No. 12 S.W.G. The guard wires are ¼-inch galvanised steel strand wire. The guard wires are fixed in accordance with the regulations of the Board of Trade.

The feeder pillars are cast-iron boxes with back and front doors, contain marble panels having break switches, bus bars and lighting switches fixed, also marble terminal board.

At each girder pillar four connections are led from the switch terminals up to the nearest pole and connected to four points of the trolley wire. The pillar is electrically connected to the rail and the feeder pole.

Each feeder pillar is provided with a telephone.

Fire Brigade Station.

The town is not in possession at present of an efficient fire station. There is a volunteer fire brigade, housed in some premises rented by the Corporation. Various attempts have been made in the past to provide the necessary accommodation, one being the incorporation with the new technical school. This was not carried out. A site was purchased in Tyler's Avenue in the central part of the town, having a frontage of 50 feet and a depth of 200 feet. The price paid was 450*l.*

The Author prepared plans, etc. for a fire brigade station. The work is now being executed, the lowest tender being 3424*l.*

Accommodation is provided for two engines, fire escapes, reel-carts, etc.; two-stalled stable, drying tower, office, recreation room, lavatories, house for caretaker, etc.

The front elevation is faced with Ruabon bricks with Portland stone dressings, plinths and thresholds of hard York stone, roof covered with Cumberland green slates, engine room walls faced with white glazed bricks, grey stock bricks for remainder of work, floor of engine room wood paved, recreation room wood block floor, floors throughout fireproof, divisions between rooms on upper floors double expanded metal plastered. The engine-room and stable doors fitted with simultaneous quick opening apparatus. The premises will be lighted by electricity.

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Scheme for the Housing of the Working Classes.

This question has been much discussed during the last two years. Although at first sight it would appear that Southend was not troubled with overcrowding, yet owing to the scarcity of houses of the cottage class houses of higher rental were crowded with two or more families and lodgers.

In July 1900 the late Medical Officer of Health, Dr. Waters, and the Author prepared a joint report on the proposed provision of 60 houses. The estimates given below show that the scheme could be carried out without a charge on the rates.

Estimate of Cost.

	£	s.	d.
5 acres of land, at 300*l.*	1,500	0	0
750 lineal feet 40 feet wide road, and sewer, at 30*s.*	1,125	0	0
40 houses class "A," at 230*l.*	9,200	0	0
20 houses class "B," at 185*l.*	3,700	0	0
Contingencies	725	0	0
Total	16,250	0	0

Estimated Annual Charges.

Repayment on land (50 years)	61	1	11
Repayment on road (30 years)	58	5	3
Repayment on buildings (40 years)	580	18	1
Rates, taxes and insurance	206	4	0
Repairs, collection	126	0	0
Total	1,033	9	3

Estimated Receipts from Rents.

40 houses at 7*s.* 9*d.* per week	806	0	0
20 houses at 6*s.* 3*d.* per week	325	0	0
Total	1,131	0	0
Deduct annual charges	1,033	9	3
Estimated annual profit	97	10	9

Class "A" house contains sitting room 13 feet by 8 feet, kitchen 13 feet by 10 feet 6 inches, scullery 10 feet by 8 feet, 3 bedrooms 13 feet by 8 feet, 10 feet 6 inches by 9 feet, and 10 feet by 8 feet.

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Class "B" house contains kitchen 13 feet by 10 feet, scullery 13 feet by 8 feet 6 inches, 2 bedrooms 13 feet by 8 feet 6 inches and 13 feet by 10 feet.

Each house is provided with a bath placed in the scullery, with a movable top; this should be a very economical and efficient method of providing this very necessary article in every house.

The houses are semi-detached; by the terms of the conveyance the land had to be divided into plots of 25 feet frontage with a depth of 125 feet.

The land has been purchased and a loan sanctioned for the scheme after a lively inquiry where much opposition was made. Tenders have been received for the erection of 40 houses, but the Council have decided not to proceed at present with the work; this with a bare majority.

If the scheme is carried out it must be claimed that the Corporation have approached the question in a very liberal spirit and made model provision for the working classes who will tenant the property.

Sea Front Improvements.

The existing provision in the shape of marine parades and esplanades is inadequate to accommodate the large masses of people so frequently assembled there. The question of carrying out improvements in this direction have frequently been discussed, and many schemes have been prepared and submitted for adoption. No scheme for the central portion has yet been adopted.

The Author prepared a scheme in 1899 providing for a continuous parade and sea wall from the front opposite the Halfway House on the east, to Chalkwell Hall on the west, a distance of four miles. The estimated cost was 300,000*l*. Generally the scheme was for a roadway of a width of 70 feet with a sea wall, but the central portion was to be specially treated. About 45 acres of the foreshore was to be reclaimed. The reclaimed area to be utilised for lakes, baths, pleasure grounds, etc. Shops to be built on the north side and a marine drive on the south side. It was estimated that the receipts from this scheme would have left a profit after paying all charges

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on loans, maintenance, etc. Against this, if the work is only confined to road widening, an annual charge will be made on the rates until the loan be paid off.

Quite recently, however, schemes have been adopted for the construction of about one mile of a road 70 feet wide and a sea wall on the western end of the town. The first portion, about 650 yards long, the Corporation executed at their own cost. The estimated cost is 19,000*l.* The second portion, about 1100 yards long, is being done by arrangement with the Chalkwell Hall Syndicate, who are contributing payments amounting altogether to 8000*l.* towards the cost which is estimated to be 21,500*l.*

Technical School.

The Corporation some few years ago built a block of buildings for the accommodation of the Technical School, some of the officers of the Corporation, and the Southend Institute. They were speedily found to be unequal to cope with the increasing demands made upon their capacity, and the matter of providing additional accommodation was forced upon the Council.

In 1898 the Council invited designs for a block of buildings to contain a town hall and public offices, a technical school and free library and police station.

The designs of Mr. H. T. Hare, F.R.I.B.A., were accepted, the estimated cost being 10,000*l.*

It was decided to proceed with the technical school portion only first. This portion will cost altogether 19,000*l.*, towards which the County Council contribute 5000*l.*

This work is now in progress, and is expected to be completed by September 1902. The buildings will accommodate 345 students in the day school of science, and 150 students in the school of art.

The building stands on ground 150 feet by 70 feet. The site is at the junction of Victoria Avenue, London Road, Southchurch Road and High Street, about the centre of the town.

The building contains the following accommodation:—

Ground floor.—Hall 57 feet by 35 feet. Physical laboratory 66 feet by 20 feet, with demonstrating room and teachers' room attached, office and committee room, carpenters' shop, cloak room and lavatories.

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First Floor:—Chemical laboratory 36 feet by 34 feet, with demonstrating room and teachers' room attached; 8 general class rooms.

Second Floor:—Art rooms, total area 96 feet by 28 feet, kitchen, scullery and pantry.

The style of the building is English Renaissance in red brick facings with Bath stone dressings.

When the whole block is completed it will form a very welcome addition to the public buildings of the town.

Cliffs and Pleasure Grounds.

The Corporation own a considerable portion of the cliffs to the west of the pier, which are laid out and planted, and form a very valuable and appreciated resort for the visitors in the season. The difficulty of keeping the turf on the upper portion is an increasing one, and the drastic one of fencing in for alternate seasons appears to be the only effectual remedy.

The Corporation own various "greens" in the Lower Town, which have been recently enclosed, planted and turfed.

In addition to the above the Corporation have just negociated the purchase of Chalkwell Hall and grounds (about 23 acres) for a public park, at the price of 16,750*l*. This lies to the west of the town, and was one of the few remaining examples of sylvan scenery to be seen in the neighbourhood. It will prove a great boon to inhabitants, and an attraction to the visitors.

In addition to the above sum, of course, further sums will have to be expended on the laying out.

Street Lighting.

The gas-works are owned by the Southend Gas Company, who manage their works so well that there is little cause of complaint given. The system adopted for the general street lighting is the incandescent (Welsbach), and very good results are obtained. The lamps are placed on an average 65 yards apart. The candle power of a lamp with new mantle is 50, with a consumption of 4 cubic feet of gas per hour. The company contract with the Corporation for street lighting, finding

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mantles, burners, and maintaining same at the following rates :—

	Per annum. £	s.	d.
For lamps extinguished at midnight	2	15	0
For all-night lamps	4	0	0

The street lighting of the town costs at the present time 2620*l.* per annum; the rate of increase being about 15 per cent. per annum.

Public Conveniences.

Various public conveniences containing accommodation for both sexes have been erected. A total sum of 8812*l.* has been expended on three buildings, all underground or partially so. The income for last year's working was 980*l.*

In the winter time the conveniences are only partially opened, the attendants being dispensed with.

The last conveniences erected were opened last summer, and are situate in Marine Parade. The building is circular, 48 feet in diameter, and is 6 feet below the ground level. The materials used are of the character usually used in similar buildings, and call for no comment. In order to insure perfect watertightness the whole is encased in an envelope of asphalt round the walls and under the floor.

Infectious Hospital.

The Corporation possesses an infectious hospital, containing accommodation for about 24 patients.

The buildings comprise—Administrative block; typhoid ward; diphtheria ward; scarlet fever block; laundry; disinfecting station (fitted with a Washington-Lyons steam disinfector); store rooms, etc.

The total amount spent on the institution is about 6000*l.*

Recognising that extensions are now absolutely necessary, the Corporation recently bought two acres of ground adjacent, and are now considering a scheme for providing additional accommodation. This is a very good investment, as had the land not been secured it would speedily have been built upon, and extension could only have been secured by having a branch institution, with all its necessary increased costs, or the abandonment of the present one altogether and the building of a central hospital.

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Cliff Elevator.

One of the most recent novelties to be introduced into the town is the electric travelling stairway erected on the cliffs.

It is an inclined structure of box-girder section, on which travels a moving floor composed of wooden slats secured to an endless linked chain. The motive power is provided by an electric motor 30 horse-power.

The stairway travels at 2 feet per second, and carries a continuous stream of passengers. It can hold 100 at one time.

The total lift is 84 feet, and the length of the stairway is 160 feet. The stairway is covered and is lighted by electricity.

The Corporation receive a royalty on the receipts and supply electricity at 3*d*. per unit.

DISCUSSION.

Mr. T. H. Yabbicom: It is with very great pleasure that I rise to propose a vote of thanks to Mr. Fidler for the able paper he has contributed to-day. It shows that he has a very energetic Corporation anxious to do everything they can for this rising and important community, and also that the Corporation have in Mr. Fidler an able and willing surveyor to carry out their wishes. We all, or most of us, know what an immense amount of labour must have been involved in preparing such a contribution to the literature of our Association as this paper, and I am sure our gratitude must be very great to any surveyor who in the midst of the multifarious duties he has to carry out will give his spare time to compiling for our benefit so much valuable information. I may be permitted to touch on one or two points raised by Mr. Fidler. Respecting the Private Street Works Act, 1892, I think the weak point is giving the justices, who are not experts in road making, a sort of veto over the wishes and decisions of a Committee or Council, who have devoted a very large amount of time to the subject. Then, in dealing with tramway questions, Mr. Fidler referred to the order which provided that road material taken from the site of the permanent way shall be removed to the store of the road authority for the district. This Mr. Fidler says is unjust, and I quite agree with him. The principle I have acted upon is,

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that all materials found on a road, and capable of use in reconstruction, should be used, and all material which cannot be used in reconstruction should be sent to the persons who have charge of the road. The use of basalt lava setts appears to me to have been a sort of middle course. We all know that we cannot get a thoroughly hard and long wearing material such as granite which will not become slippery; and the softer materials like wood do not wear long. I have noticed that there are signs of grooving already next the rails—a point where one would expect a material like basalt to show signs of wear. The point which struck me most in the paper was the reference to the housing of the working classes. I should have thought that in a place like Southend there would have been no lack of private enterprise to have built houses to almost any extent for every class for which they were required. It does not seem to me the duty of the local authority to enter into competition with builders and contractors, if the latter are willing to provide the accommodation required. The reason given is that the present houses are occupied by two or three families for purposes of economy. Then we are told it is proposed to build forty houses to let at 7*s.* 9*d.* per week, and twenty houses to let at 6*s.* 3*d.* Those are rents which I am sure labourers and people of that class cannot afford to pay, and if that is so it will simply result in these houses being occupied by two or more families as at present. How would it be possible for a labourer earning even 30*s.* a week to pay the lower rent of 6*s.* 3*d.* for one of these houses? If houses are required for the labouring classes—such as it is the duty of some of us in the large centres to put up—they must be built to let at a much cheaper rent, and not give the liberal accommodation which it is proposed to do under this scheme. Allusion is made in the paper to the infectious hospital; but I see no mention there of accommodation for small-pox cases, a provision which ought to be made in every community. I think the Corporation would be more properly employed in putting up a pavilion to deal with cases of small-pox than in troubling themselves about providing artisans' dwellings. I have pleasure in proposing a vote of thanks to the Author for his admirable paper.

Mr. W. HARPUR: I rise with very great pleasure indeed to second the vote of thanks to Mr. Fidler for his very able paper

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and for the very interesting information he has given to the meeting. I would like to ask two or three questions upon the paper. Mr. Fidler states in reference to the sewerage scheme, that sanction was given for the gravitation or high-level sewers pending arrangements with landowners for sites and easements for the low-level portion. I should like to know whether I am to gather from this that the Local Government Board withheld their sanction to the scheme until the local authority had made their arrangements for the easements and the land required for the work, and I should like to know whether it necessitated the purchase of land for the work. Further, were the works entirely within the borough or any portion outside the borough? I gather from the paper that part of the tramway scheme is without the district. With respect to the paragraph relating to rails and fishplates, I should like to know whether the whole of the rails have an additional guard rail, and if so, why it has been found necessary, and whether it is not dangerous to vehicular traffic.

Mr. W. HOWARD-SMITH: Where is that?

Mr. W. HARPUR: On page 59. As to the paving, I should like to know whether the basalt is that supplied by the London Basalt Stone Company. At the present time, with so much controversy going on with reference to wood paving, I think we cannot say too much upon that subject. The Author says, "Some trouble has arisen from expansion of the material, the blocks rising above the surface or forcing the points out of gauge. This is a very bad quality that wood possesses and entails constant attention to correct the inclination to move outwards." Well, that is so, and I agree there is very great difficulty in knowing in what condition wood should be laid down. I have been laying down a large quantity of wood paving and my experience has been the reverse of Mr. Fidler's. The jarrah, which I have had in stock for nearly two years, instead of expanding has contracted considerably, leaving scores of gaping joints of 1 inch to fill up. Now the question is, what is going to be the state of affairs when we get the wet upon it during the winter months after the heat wave of the summer months? Are we going to have the experience of Mr. Fidler of expanding blocks rising above the surface? The question of wood paving is being discussed very keenly at present, particularly in London. Although I have a large quantity of jarrah I am having 1500

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loads of that rightly or wrongly condemned red gum, and I shall soon be having an opportunity of testing its quality. I believe there is nothing like getting one's own experience, instead of accepting every statement which is made in the newspapers. Some years ago I had a large quantity of jarrah wood blocks supplied, and I then found it impossible to get blocks cut true to gauge. I put down one of Messrs. Temperley's saws, and with that saw was able to cut from 35,000 to 40,000 blocks a day (when working night and day), all of which are absolutely true to gauge. If any of you want to lay down good wood pavings it will pay you to put down your own sawmill, cut the blocks and reject any if wrong in gauge. If that is done you will have far better work than by taking the stuff as it comes from the contractor's mill. As to the housing of the working classes, I quite agree with Mr. Yabbicom: I think the class the municipality has to provide for is the lowest class. Unless cottages are put up which can be let for 4*s.* a week for men earning 1*l.* 1*s.* a week, I do not think a municipal scheme will be of any use whatever.

Mr. A. E. Collins: I desire to support the vote of thanks to Mr. Fidler for his admirable paper. I am sure Mr. Fidler has done wonders in his work at Southend. I should like to know the nature of the records which are kept of the daily working and inspection of the outfalls at the foreshore. With reference to the use of the Anchor sole plate, I notice you bolt them, while at Plymouth they rivet them. Personally I think that riveting is superior to bolting. When at Plymouth I looked at the riveting of the plates, and I thought the people who were doing the work were doing it exceedingly well.

Mr. E. J. Silcock: We seldom have a paper presented to us containing so much definite information. That especially applies to the Author's remarks on the tramway, giving practically a specification for constructing a tramway, and which I have no doubt will be of great service as a work of reference. With regard to the tramways, the only point I should like to call attention to is the length of the rails, 45 feet. The difficulty of keeping the joints perfect has been one of the greatest difficulties of tramway work, and the more we can reduce the number of joints the better. Of course 45 feet rails are a great improvement upon 30 feet, but there is no reason why we should not have 60 feet lengths, as rails are being rolled 60 feet long.

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With regard to the sewerage scheme, I should like Mr. Fidler in his reply to give us some information as to the relative levels of high and low water, the outfall sewer and the storage reservoir. It is always difficult in designing with tidal outfalls, to decide where the level of the outfall shall be in relation to high and low water and the adjoining land. Will Mr. Fidler also give us an idea of the area served by the low-level sewer from which the sewage is pumped? I have not had the pleasure of being here before and do not know the lay of the ground, but from the glimpse I have had this morning it seems to me that the greater part of the district is above the level of the seashore, and that there would not be much difficulty in making a sewer discharge at all times of the tide. The capacity of the storage reservoirs is only a small proportion more than the ordinary dry weather flow, and as there is no reference to a separate storm water system I presume the storm water is all discharged from the same outfall. In passing I see that the water company used to charge 1*s.* per 1000 gallons for water for street purposes. I think that that will be rather interesting to one or two of my friends here to-day. I should like to emphasise the necessity of having a thoroughly good hospital for infectious diseases, and especially would I impress upon the Corporation the desirability of having accommodation for private patients in isolation wards. In a place of this kind, with a large number of visitors, it is of the utmost importance that there should be private wards where parents can take their children and have charge of them themselves. I have recently had a personal experience myself of the necessity of such provision in a town where I was staying, where there was no accommodation except in the general wards. I am sure many people would be very glad indeed to have a private ward where they could take an infectious case, and to pay such a rental as would practically make the wards self-supporting.

Mr. W. HOWARD-SMITH: The data as to cost which the Author has given us impress me with the economy with which these particular works have been carried out: the figure given of 4775*l.* per mile of single line seems to me to be exceedingly low. Of course, the state of the markets for rails, setts, etc., at the time of letting a contract largely governs the cost of such works. I can well understand the Author's reference to this point, as I have myself had experience within the last three years of a variation

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of nearly 40 per cent. in the cost of rails, and some 50 per cent. in that of granite setts. While within this period there has been a distinct advance in the quality and accuracy of rolling of rails, especially when of English manufacture, granite setts have shown marked deterioration in their dressing, with perhaps an exception in those from the best British quarries.

But the first cost of a tramway is not the only thing to look at, regard should also be given to the question of the probable cost of maintenance, which is already becoming a serious item on some tracks constructed only within the last two or three years.

Undoubtedly electric traction is most punishing, due to the high speeds, heavy cars and frequency of service, and its effect on a track is quickly apparent, more especially at the rail joints, unless efficient means for fortifying these has been employed.

One important point achieved is the anchorage of the rails to the concrete underbed by means of the joint plate whereby all lateral or vertical movement of the rail is prevented. I believe it has now become generally recognised as an essential of a good track.

With long rails such as those of 60 feet which Mr. Silcock has advocated there is generally a certain amount of "spring" due to the minute wave-like movement upon the passage of a car; the effect of this, where the rails are not anchored down, is to lift the abutting paving and to cause "creep," singular instances of which may be seen on many tramways.

Personally, I regard 45 feet more desirable than 60 feet as a standard length of rail. In any case at Southend the latter would have been impracticable as being too long for water carriage.

Upon the paving question, I am not an advocate of wood, which, whether soft or hard, is often the source of much trouble when laid on tramway tracks, and I do not believe any tramway engineer would so use it for choice.

The basaltic lava setts which have been used at Southend appear to have much to recommend them, especially for tramway work. I have inspected many miles of tramway on the Continent paved with these setts, and the testimony to quietness, non-slipperiness and durability is greatly in their favour. The particular plan, usually known as the "throw over," which has been adopted for the passing places, is not one which I favour as

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it is somewhat inimical to vehicular traffic, although I quite appreciate that the desire has been to get a straight "run in"—a most desirable thing; this could, however, have been attained with a "modified diamond" plan which gives sweeter running and also has much to commend it from a vehicular point of view.

Referring to the comparative advantages of the various methods of overhead construction, I believe the "span wire" with direct under-running trolley, will eventually be regarded as æsthetically less objectionable than either the "bracket arm" or "centre pole" systems, and it is certainly preferable from a constructional and working point of view.

Mr. T. WALKER: Mr. Fidler would perhaps give us the relative cost of pumping by electricity and by gas.

Mr. F. W. PEARCE: As representing one of the suburban districts in somewhat closer contiguity to the metropolis than Southend, I should like to lay a little stress upon two points in the paper which have not been touched upon. I should like to congratulate Mr. Fidler and his Corporation upon the thorough manner in which they are dealing with new buildings and new streets. Those are questions which touch some of us in suburban districts very closely indeed. Where there is a large increase of building going on without sufficient assistance for proper supervision, one is always face to face with a very great difficulty. Unfortunately some local authorities, while expecting us to look after such matters, do not provide us with the assistance to do it. That is not so at Southend. They not only recognise the necessity but also provide the requisite assistance, and I am satisfied the outlay will be well repaid. Then, with regard to new streets, I believe it is the best policy to make up the roads with the least possible delay in the most thorough manner, and to maintain them, especially in a residential district, in a first rate condition.

The vote of thanks having been accorded by acclamation,

Mr. FIDLER, in reply said: I will deal very shortly with the questions which have been put, but before doing so I must express my appreciation of the criticism which the paper has called forth. In reply to Mr. Yabbicom, I must admit I quite agree with him as to the difficulty of putting in operation the Private Street Works Act of 1892. As to the slight grooving which Mr. Yabbicom referred to in the tramway paving, we get that with

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all other kinds of material equally with basalt lava. With regard to the housing scheme, it may be a matter of surprise to gentlemen coming from densely populated manufacturing districts to hear that a scheme for the erection of houses at 7*s.* 9*d.* and 6*s.* 3*d.* per week should be called a scheme for the housing of the working classes, but I can only say that the conditions existing in Southend are not on all fours with those in manufacturing towns. The working classes in Southend will be only too glad to pay the rents I have mentioned, because they pay more at present. With respect to the provision of small-pox hospital accommodation, the present Infectious Diseases Hospital referred to in the paper is intended only for cases of scarlet and typhoid fever and diseases of that kind; but there is a permanent structure of corrugated iron situated in an isolated position, about a mile and a half from the town, for the reception of small-pox patients, but the town has every reason to congratulate itself that it has not been put to any use for six years. With regard to the remarks of Mr. Harpur and to the reason for the Local Government Board delaying their sanction for the Prittlewell main drainage works, I may say it was absolutely necessary to purchase land for the scheme. The position of the outfall from the pumping station is situate half a mile from the nearest road. In future years it may not be necessary to pump, but substitute for the present outfall a deep low-level gravitating outfall, but to do that now the cost would be very great. The whole of the works are within the borough, and it was not necessary to purchase any land outside the district. The Local Government Board withheld their sanction until provisional agreements had been made with the owners of the land and the railway company whose line we had to cross. The negotiations were exceedingly protracted as the first negotiations proved ineffectual. The lip of the curved rail is $\frac{1}{4}$-inch higher than the head of the rail. The basalt lava is provided by the London Basalt Company. Mr. Collins remarked upon the Anchor sole plate being bolted to the rail and expressed a preference for riveting. That is simply a matter of opinion. Riveting has its good points, but in a lesser degree the same objection might be urged to riveting as to the Falk cast weld joint. The records made by the building inspectors consist of a recapitulation of the plans, thickness of the walls, thickness of timbering, the testing of the drains, the number of visits paid, and when the

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house was occupied. Mr. Silcock referred to the length of the rails, and the adoption of 60-feet lengths. Mr. Howard Smith has replied fully to that question, and I thoroughly agree with him. Of course, in a tramway, we would like to dispense with joints altogether, and have one continuous rail. Perhaps the advance of science will enable us to achieve that some day, but until then I am in favour of 45-feet lengths. The question of the main sewerage is so important and interesting here that it will afford me pleasure to supplement the information I have given in the paper with respect to the sewerage scheme. I may say that the low water mark is 5·6 below O.D., and in the Western Valley the top water level of the land is 38 feet above O.D. Both sewage tanks discharge under pressure and into one outfall. In conclusion, I should like to say how much I appreciate the remarks of the Members present in congratulating the Council upon their progressiveness. Following upon that I must say that the Council have provided proper and adequate assistance for the immense amount of work which has to be done here. I also wish to say of my staff of assistants that they give me the most loyal support in the work I have to do, and I appreciate their loyal efforts. Lastly, I wish to express my gratitude for the honour which the Association has conferred upon the town in coming here for this meeting, for their kind words in reference to the Corporation, and for their hearty vote of thanks to myself in recognition of the labour involved in the preparation of the paper.

The Members then proceeded to view the various public works described by Mr. Fidler in his paper. At the conclusion of the visits the Mayor entertained the Members of the Association to luncheon at the Kursaal.

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VISIT TO MESSRS. MILLAR'S WORKS AT PURFLEET.

September 27, 1901.

The Members travelled by special train from London to Purfleet where they were afforded an opportunity of inspecting the wharves and saw-mills of Millar's Karri and Jarrah Forests, Limited. On arrival at Purfleet the Members were received by Mr. Temperley and other officials of the Company, and were conducted over the whole of the extensive works. The works, which comprise an area of 42 *acres, have been laid out in bays, each served by a railway siding. The saw-mills are equipped with Temperley's patent cross-cut saws, driven by electric power, each saw turning out* 6000 *blocks an hour. The pier at which the timber is landed from the steamers is built entirely of karri. The curved approach is* 400 *feet in length, and the pier head* 300 *feet in length by* 50 *feet in breadth.*

The Members were afterwards entertained to luncheon, Mr. C. Temperley presiding, supported by the President of the Association (Mr. E. G. Mawbey) and the Directors and officials of the Company.

The Chairman welcomed the Members of the Association to Purfleet, and expressed a hope that the visit had proved an interesting and instructive one.

Mr. E. G. Mawbey (President) responded, and a hearty vote of thanks was passed to the Chairman and Directors of the Company for their courteous hospitality.

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DISTRICT MEETING AT NUNEATON.

October 19, 1901.

Held in the Assembly Room of the Conservative Club, Nuneaton.

E. GEORGE MAWBEY, M. INST. C.E., PRESIDENT, *in the Chair.*

THE Vice-Chairman of the Council (Mr. Councillor T. Horton) received the Members and gave them a hearty welcome to the town.

The President, on behalf of the Association, thanked Mr. Councillor Horton for the kind welcome he had offered to the Members.

Mr. J. S. Pickering (the Hon. District Secretary), whose recovery was noted with much pleasure by the Members present, then read the minutes of the last District Meeting, which were duly confirmed and signed.

The following paper was then read and discussed.

MUNICIPAL WORK IN NUNEATON.

BY J. S. PICKERING, ASSOC. M. INST. C.E.,
ENGINEER AND SURVEYOR.

GENERAL.

THE name of the town was originally Eton, Étone, or Eaton, derived from the Anglo-Saxon "ea" water and "tun" a town, the prefix "nun" having been probably added when the ancient nunnery was founded in King Stephen's time by Robert, Earl

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of Leicester, about the year 1150. Some portions of the priory still remain.

Readers of the works of George Eliot will find much to interest them, for besides being the birth-place of the great novelist, the town and district abound with the interesting scenery and the objects and surroundings of her early life, made famous by her graphic descriptions. But—to use her own words—"dear old brown crumbling picturesque inefficiency is giving place everywhere to spick-and-span, new painted, new varnished efficiency, which will yield endless diagrams, plans, elevations and sections, but alas! no picture."

Nuneaton ranks amongst the most important manufacturing towns in the Midlands, and its rapid growth seems to point to a still greater future importance. It has excellent railway accommodation and its industries are of a very varied character. It contains collieries, brick-works, stone quarries, sanitary-pipe works, hat factories, iron foundries, fellmongers' works, worsted-spinning, plush, elastic web, ribbon and other factories, etc. The Urban District comprises Nuneaton, Chilvers Coton, Attleborough and Stockingford, an area of over 10,000 acres. The population in 1891 was 15,246, and the recent census shows it to have increased to 24,995. The rateable value is 100,078*l.* The outstanding loans (apart from the water undertaking, which is under a special Act) amount to 82,373*l.*, or under half the limit allowed in the Public Health Act, 1875. The Council are now considering the desirability of obtaining a charter of incorporation.

Streets and Roads.

The total length of roads repairable by the Council is about 37 miles. Ten and a quarter miles of these are "main" roads, towards the maintenance of which the County Council contribute 1700*l.* per annum under an agreement made for a term of 3 years, the Urban Authority undertaking to use not less than 1600 tons of macadam per annum during this period. The macadam for the repair of the roads is obtained from a quarry belonging to the Council. It is machine broken and can be produced for about 2*s.* 6*d.* per ton.

Tar-macadam roads are made with success, and it is proposed to adopt this type of road more extensively. A road so constructed possesses all the advantages of an ordinary macadamised

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road, and the additional advantages of wearing longer, being more sanitary and requiring less scavenging and watering. A tar-macadam road can be made complete for about 2*s.* per super yard, with 3 inches of macadam as foundation and 1½ inches of chippings as topping, including cost of material, cartage to depôt, heating and tarring material, scarifying road and removing old macadam, cartage from depôt, laying and steam-rolling. Concrete slabs for footpath paving are made by the Council, and can be produced of equal quality to any purchased and at a less cost.

New Streets.

New streets are invariably made and completed (with the exception of the footpath pavements) and taken over by the Council before being built upon, consequently the usual disagreeable proceedings and disputes inseparable from the compulsory making up and apportionment under the Public Health Acts are avoided. The amount for the paving of the footpaths is deposited with the Council, who lay down the pavements as the buildings in the street are completed. The chief objection to this system is that the carriage-way is cut up by the heavy traffic from building operations and by drain, water and gas services, and often has to be re-macadamised at the cost of the general rates before the street is fully built upon. Notwithstanding this, however, the system is much better than the practice in most towns of allowing a street to remain unformed, and consequently in an insanitary condition year after year, until the authority deem it advisable to serve the owners with notice to properly construct it. The objection moreover would be removed if, instead of laying a thickness of 5 inches at one operation, as at present, the macadam were laid in two coats, the upper layer being spread and rolled after the street had become built upon, or after the lapse of a fixed period at the discretion of the Council's surveyor.

The Council supply a printed specification and type drawings showing the construction of the streets, and the details of sewer manholes, flushing chambers, gullies, etc., which are signed and deposited by the persons submitting plans of intended streets.

The water and gas mains are laid in all new streets while in the course of construction by the Council and gas company.

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All new streets are provided with sewers and separate surface water drains. The sewers are ventilated through iron columns, and are provided with automatic flushing chambers supplied with water from the public mains.

A long established practice of the Council allows the kerb and channels to be made of blue brick ware, a material which does not compare favourably with granite.

A new street, including blue brick footpaths, can usually be made complete for about 50*s.* per lineal yard.

Sewerage.

The drainage of the district is carried out on what is known as the "separate" system. The total length of main sewers (apart from surface water drains) is about 14 miles, and a further length of four miles is about to be laid for the drainage of an outlying district, and to receive the sewage from a portion of the district of the Atherstone Council, which it has been decided to receive and treat for a period of thirty years at 5*d.* per 1000 gallons.

A large number of 6-inch ventilating shafts have been provided for ventilation and the street gratings closed, and this system is adopted in all extensions. A large chimney shaft at one of the factories in the town is connected with the sewers for ventilation purposes, but its influence is not perceptible in the sewers for a distance of more than 100 yards or so. The experience in most cases where this system has been tried appears to coincide with that of the Author, that chimney shafts are not practicable for ventilating any extensive system of sewers.

House Drainage.

An uniform charge of 25*s.* for each drain connection from the main sewer to the boundary of the street is made, and is payable in advance. On each system of house drains an inspection chamber provided with a disconnecting trap is built. Before being approved the drains are tested under pressure with water.

Public Lighting.

The gas undertaking is in the hands of a company, with whom the Council have a contract for public lighting. The

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company provide and maintain the columns and lanterns and light and extinguish the lamps for 3096 hours during the year at 3*l.* 1*s.* per lamp. After allowing for lighting and extinguishing, cleaning, 5 per cent. interest on capital outlay, and 5 per cent. for depreciation, the cost of the gas at five feet per hour works out at 2*s.* 5¼*d.* per 1000 cubic feet. Several of the thoroughfares have been successfully lighted with incandescent gas lamps. An extra charge of 7*s.* 6*d.* per annum is made for an incandescent burner.

Scavenging, etc.

Previous to the inauguration of the water-works, thirteen or fourteen years ago, the "privy" or "midden" system was general. The substitution of water-closets has necessarily been a somewhat gradual process, and more than half the houses are still provided with privies. It is to be regretted that the powers of a sanitary authority are so limited in bringing about the abolition of the insanitary "privy" system, especially in a populous district.

The Council have recently undertaken the weekly removal of house refuse where suitable dust-bins are provided, and this is undoubtedly a step in the right direction.

The disposal of night-soil has been a very troublesome matter. Although of some manurial value, its application to the land is objected to on account of the large proportion of useless refuse it contains, and it will not compete favourably with the artificial manures in use. It is now taken to a site on the outskirts of the town, from which farmers cart it away at their convenience free of cost. The supply, however, is greater than the demand, and the material is gradually increasing.

The following figures show the quantity of night-soil and house refuse removed during the past four years and the cost of removal:—

	1897	1898	1899	1900
Total cartloads removed from wet ashpits and privies	5,323	5,749	7,169	7,049
Ditto from dry ashpits	1,543	1,647	1,868	2,518
Total cartloads removed	6.866	7,996	9,037	9,567
	s. d.	*s. d.*	*s. d.*	*s. d.*
Cost per cartload—wet ashpits and privies	3 6	3 6	2 11½	2 10¼
Ditto dry ashpits	2 1½	2 1	2 0	2 2¾

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It will be noticed that the dry refuse in connection with water-closets is increasing, while the highly offensive privy refuse is on the decrease.

Refuse Destructor.

The contract for a refuse destructor has been given to Messrs. Meldrum Bros., and this is to be erected at the present sewage works at once. The steam generated will be utilised for raising the sewage of the district.

Council Offices, Fire Station, Depôt, etc.

The Council offices, fire station, firemen's and caretakers' houses were built from the Author's plans ten years ago. At the rear of these buildings there is a spacious yard for the use of the highway and scavenging departments, with stabling, steam-roller sheds, blacksmiths' and carpenters' shops, store-rooms, etc. The town is in possession of an excellent fire brigade, which is managed by a committee of the Council. Electric bells are laid from the fire-station to the firemen's houses.

Electricity Works.

The Council have recently purchased the undertaking of the Nuneaton Electric Company. The author is now engaged in completing an entirely new generating station. This contains two Babcock & Wilcox boilers, each with a heating surface of 1827 square feet, to work at a steam pressure of 160 lbs. per square inch; two steam dynamos by Willans & Robinson, 150 k.w. and 72·5 k.w., and one by Clarke Chapman, 80 k.w.; a battery of 246 cells having a capacity of 600 ampere hours by the Hart Accumulator Co.; a steam economiser composed of 192 tubes, with motor driven scrapers by Green & Son; switch-board by Edmund Charrington; condensers by T. Ledward & Co.; balancer booster by Johnson & Phillips; and motor pump, for condensers, by Johnson and Phillips. The mains are triple concentric, and have been supplied and laid by Johnson and Phillips. The feeders are lead covered and drawn in Doulton conduits. The distributors are armoured and laid direct in the ground. The buildings have been erected by Mr. Thomas Smith, of Nuneaton. A loan of 18,000*l.* has

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been sanctioned for the works, but this does not provide for any extension of the cables, which, at present, are only laid through a few of the streets of the town.

Free Library.

A free public library, with reading room, has recently been erected by the Council, and appears to be much appreciated.

Electric Tramways.

A provisional order has been obtained by the Nuneaton and District Light Railways Company for the construction of about 8½ miles of electric tramways on the overhead trolley system. The Council have taken advantage of the order to carry out, in conjunction with the company, some important street widenings. The Council will have power to utilise the standards of the company for the purpose of sewer ventilation, or for attaching wires and brackets for electric or gas lamps.

Water Supply.

The Council purchased the undertaking of the East Warwickshire Waterworks Co. in 1897 for 30,000*l.*, the Company relinquishing 10,000*l.* of their capital for the benefit of the town. Since then a further capital of 35,000*l.* has been expended on a new pumping station, filter beds, an additional reservoir, and in extending the mains. The works have been designed and carried out by the Author.

Considerable difficulty has been experienced in obtaining a water supply. Two deep wells sunk by the late company in the permian strata yielded an insufficient supply, but contain a useful reserve of water which can be utilised in case of emergency.

In sinking two new shafts for coal Messrs. Stanley Bros. met with so large a quantity of water that they had to be abandoned, and these have been acquired by the Council, together with three Lancashire boilers, chimney shaft, and a site of two acres of land for a pumping station. The water from these shafts is used to supply the district. The erection of the

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pumping machinery and the new engine house are now nearing completion.

The pumping machinery has been supplied by the Worsley Mesnes Ironworks Co., Wigan, at a cost, including foundations, etc., of about 6000*l*. The engines and pumps are in duplicate, and each set is capable of raising 50,000 gallons per hour from a depth of 130 yards and delivering the water to the filter beds under a head of 120 feet. The well is at present 120 yards in depth, and the pumps are placed at the water level, a depth of about 60 yards. It is anticipated that they will require to be lowered from time to time as the consumption of water increases. The engines are of the horizontal tandem type, compound and condensing. The high-pressure cylinders are 20 inches and the low-pressure cylinders 33 inches in diameter. The engines run at a piston speed of 360 feet per minute. Each engine is capable of working both sets of pumps, and by an arrangement of gearing either engine will work either set of pumps. The well pumps are 21 inches in diameter, and are provided with combined rams and plungers, the rams being 19 inches in diameter. They have a stroke of 5 feet, and are made to work double acting and at a speed of 90 feet per minute. The water is delivered into a small tank under the engine house floor, passing through the surface condenser on its way. It is then forced through a mile of 12-inch rising main to the filters by means of a separate plunger pump attached to the crank of the deep well pumps. Coal-dust is used in the boilers, and costs 2*s*. per ton delivered. The pumping costs in fuel about a halfpenny per 1000 gallons raised 300 feet. The water when pumped contains a quantity of iron in solution, which oxidates on exposure and produces a turbid appearance. The iron is removed and the water rendered bright and clear by filtration. There are four filters, each having an area of 200 square yards. They are composed of a depth of 3 feet of sand, under which is laid a 12-inch layer of granite chippings, the whole being supported on a false floor composed of special perforated tiles made by Messrs. Stanley Bros., of Nuneaton. The tiles are 16 inches square, and are laid loosely on rows of bricks so formed as to thoroughly drain the beds. There is a special feature in the arrangement of outlets from the beds. These are movable iron arms, which can be raised and lowered at will in order to regulate the head of water on the

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filters. When a filter requires cleansing the filtered water from another bed can be delivered into the bottom and utilised for upward washing, the dirt being discharged with the water through a swivel elbow pipe fixed immediately below the surface of the sand. The water from the filter beds is conveyed through a 15-inch main by gravitation to the covered service reservoirs, which have a capacity of 800,000 gallons. The walls of the reservoirs are built of brickwork and the floors are of concrete. The roofs consist of a series of brick jack-arches springing from brick arched walls. The floors and walls are rendered ¾ inch thick with cement mortar. Upon leaving the reservoirs the water is measured on its way to the town by means of three 6-inch Kent's meters.

There are now nearly 20 miles of distributing mains in the district.

The consumption of water is about 400,000 gallons per 24 hours. The quantity used for domestic purposes works out at an average of 13 to 14 gallons per head of the population supplied. The head of water in the town is 200 feet. The house services are generally of galvanised steam tubing. The Council lay from the main to the boundary of the street, and charge 20*s.* for each connection. The mains are tapped under pressure with Morris' drilling and tapping apparatus. The services are tested under a pressure of 300 pounds per square inch before being approved by a "Longridge" test pump.

Sewage Disposal.

The question of sewage disposal has been a very difficult problem, particularly on account of the foul character of the sewage due to the waste liquors from the wool scourers, fellmongers and hat factories.

The existing sewage works are in close proximity to the town and occupy a site of about 6 acres.

For many years the process of treatment was chemical precipitation and artificial filtration. The results were not altogether satisfactory and the working expenses were very high. Moreover, the Local Government Board refused to sanction any loan for extensions without the acquisition of land for filtration purposes, and this was not available in the neighbourhood of the works.

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Upon the introduction of the bacterial system some few years ago it was decided to make a trial of the process. This proved so satisfactory that the treatment was applied to the whole of the sewage, with a result that a very considerable saving has been effected in working expenses.

After passing through a screening chamber the sewage flows into a pump well 50 feet in depth. From this it is pumped and delivered into two roughing tanks each 13 feet deep and 20 feet diameter. The sludge deposited in these tanks is lifted automatically to within 2 feet of the surface by the pressure of sewage. It is then dealt with in two of Johnson's sludge presses.

The sewage then flows into open septic tanks or coarse contact beds. There are three open tanks, each of a capacity of 120,000 gallons. There is an area of 1708 yards of coarse contact beds, and in order to test various materials they have been filled with coke, macadam, broken pots, ashes, and broken bricks. A portion of the sewage is treated in a closed septic tank having a capacity of 120,000 gallons. From the open and closed tanks and the coarse contact beds the sewage passes into fine contact beds of which there is an area of 3564 yards varying from 3 feet to 5 feet in depth, and composed of coke dust, coke breeze, small coal and fine granite chippings. From the fine grain beds the effluent passes direct into the river.

Most of the contact beds have been made in excavation without artificial walling, the subsoil being a strong marl. There is no objection to this course if the beds are made watertight, but should they leak from one to the other, they are a source of trouble and the results are not satisfactory.

Some of the beds have been in use for three years, and all have been in operation for over two years. The coke beds give the greatest liquid capacity, but there appears to be no appreciable difference in the results as regards the various materials composing the beds.

The deep roughing tanks have been found most serviceable for intercepting the grit and other heavy matter. One of these tanks has been in regular use for over four years and has not been emptied during this period.

The closed septic tank has been in use for over two years and has not been emptied. It has liquefied (as far as can be ascertained by measurement) about 95 per cent. of the suspended matters passed through it.

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The open septic tanks have been in operation 13 months, and it has been found necessary to empty them and remove the sludge once during this period. One tank was emptied after 7 months working, another after 8 months, and the third after 9 months, the sludge from the three tanks producing about 320 tons of pressed cake. Whilst, however, the closed tank has dealt with a daily flow of sewage equal to about 50 per cent. of its capacity, the open tanks have dealt with a daily flow equal to 150 per cent. of their capacity. Both the closed and open tanks have done excellent work, particularly when the unusually large quantity of suspended matter in the sewage is taken into consideration.

It appears to be generally considered an essential part of an open septic tank that a coating of scum should be formed. After 13 months' working, however, the surface of the sewage is only partially covered with scum, but the process of liquefaction has certainly been in active operation. It is remarkable how quickly a coating was formed by covering a tank, which had been in use some months, with a light roof of boards. In less than 24 hours a scum several inches in thickness was formed.

The Author is of opinion that the treatment of sewage in open septic tanks cannot be carried on without nuisance. This may not be a serious objection to their use in some places, but it should be borne in mind. The treatment in a closed septic tank is not nearly so offensive as in an open tank, but the effluent from a septic tank has a most offensive odour, particularly if it is broken up into sprays for applying to the fine grain beds.

In designing either closed or open tanks the fact that the deposited matter must sooner or later be removed and treated should not be overlooked.

The Author's experience is that the least offensive method of applying the bacterial treatment is by the Dibden system of coarse and fine contact beds. There is no serious nuisance produced by applying the raw sewage in a fresh state to the coarse beds, and no offensive odours are given off during the periods in which the sewage is in contact with the material. The beds are so free from offensive smells that it is found impossible, as a rule, by walking over them to detect which are at rest and which are working.

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It seems to be generally agreed that about two hours is the proper time for the sewage to remain in contact with the material, and this is the Author's experience with the sewage of a manufacturing town.

The Author is of opinion that the most important matter in connection with bacteria beds is the question of their reduction in treating capacity owing to choking up. He has not yet been able to agree with the opinions expressed by some authorities that after reaching a certain stage the capacity of the beds will remain undiminished. He is inclined to the opinion that sooner or later the beds must become choked to such an extent that the material may require screening. Information on this important point is very limited and somewhat conflicting.

The following tables show the reduction in liquid capacity of four of the coarse grain bacteria beds over a period of 2½ years. The fine grain beds are not watertight, so that the information as to their capacity is not reliable. It is found, however, that they do not silt up nearly so quickly as the coarse beds.

COARSE GRAIN BACTERIA BEDS (COKE).

Date of Reading Meter.	Register of Meter.	Decrease.	Increase.	No. of Fillings between Dates of Reading Meter.	Remarks.
	Gallons.				
No. 1.					Bed first filled Feb 20th, 1899.
1899					
Mar. 23	22,200			43	
April 19	22,200			49	
May 24	21,100	1,100		63	
June 7	21,100			23	Resting from June 8th to June 17th.
July 13	21,100			46	
Aug. 16	21,100			40	
Sept. 26	21,100			57	
Oct. 26	21,100			49	
Nov. 16	20,500	600		42	
Dec. 28	20,200	300		85	
1900					
Jan. 26	20,100	100		54	Resting four days.
Feb. 12	20,100			34	Resting from Feb. 16th to Feb. 28th.
Mar. 24	19,400	700		54	Made bed up with coke.
April 28	18,500	900		91	

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COARSE GRAIN BACTERIA BEDS (COKE)—*continued.*

Date of Reading Meter.	Register of Meter.	Decrease.	Increase.	No. of Fillings between Dates of Reading Meter.	Remarks.
No. 1.—1900—*continued.*	Gallons.				
May 26	18,500			65	
June 28	18,300	200		67	
July 27	19,000		700	58	
Aug. 30	19,500		500	67	
Sept. 25	19,500			45	
Oct. 29	19,800		300	73	
Nov. 21	19,300	500		69	
Dec. 20	19,800			74	
1901					
Jan. 30	18,600	700		100	Resting three days.
Feb. 28	17,800	800		94	
Mar. 28	17,100	700		87	
April 26	17,700		600	86	
May 29	18,300		600	76	
June 29	18,600		300	67	
July 30	19,000		400	83	
Aug. 27	19,000			74	
No. 2.					Bed first filled Mar. 3rd, 1899.
1899					
Mar. 28	24,100			38	
April 20	24,100			51	
May 28	22,800	1,300		60	
June 9	22,800			30	
July 13	22,800			55	
Aug. 16	22,700	100		41	
Sept. 26	22,700			58	
Oct. 26	22,700			49	
Nov. 15	21,900	800		40	
Dec. 28	21,400	500		87	
1900					
Jan. 26	21,000	400		54	Resting four days.
Feb. 12	21,000			34	Resting from Feb. 16th to Feb. 28th.
Mar. 27	20,200	800		61	Made bed up with coke.
April 28	19,000	1,200		84	
May 26	18,900	100		64	
June 58	18,700	200		67	
July 27	19,400		700	58	
Aug. 30	20,000		600	67	
Sept. 25	20,000			45	
Oct. 29	20,200		200	73	
Nov. 22	19,500	700		73	
Dec. 30	19,400	100		72	Made bed up with coke.

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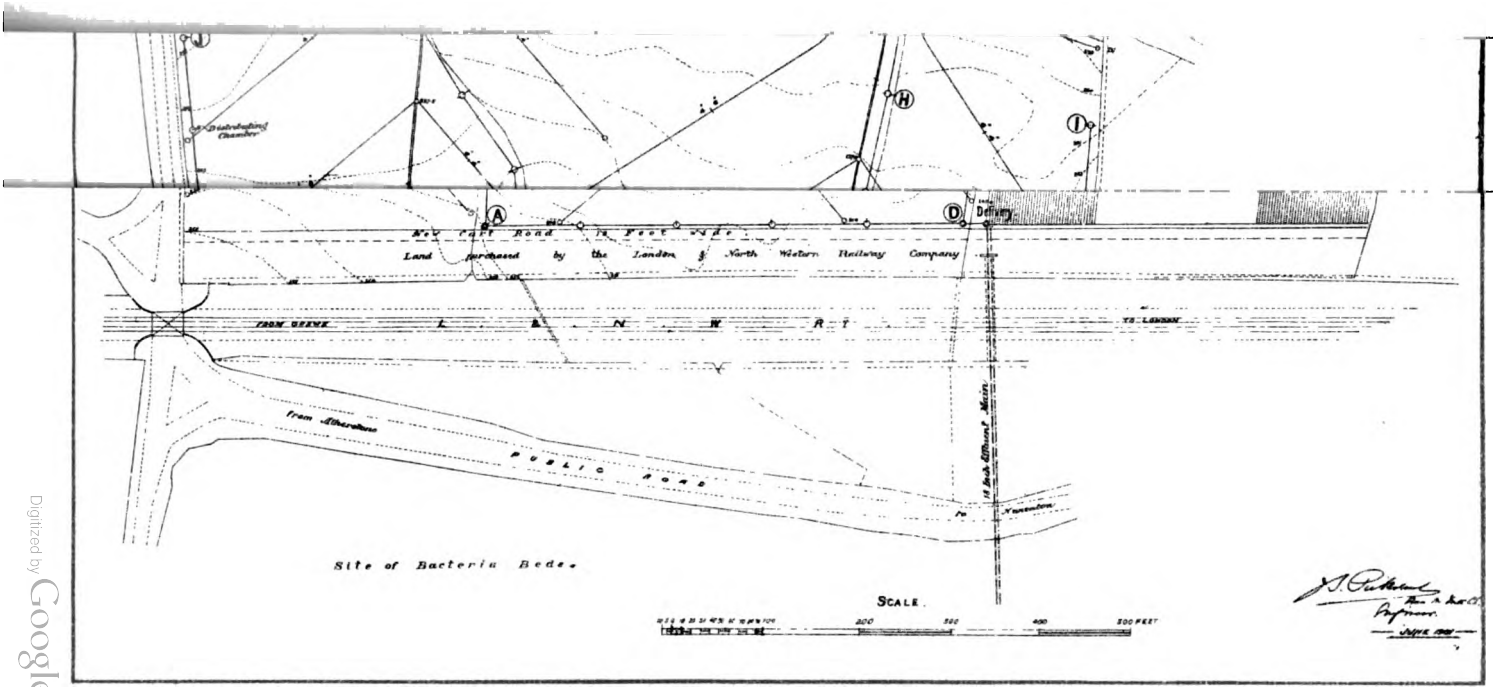

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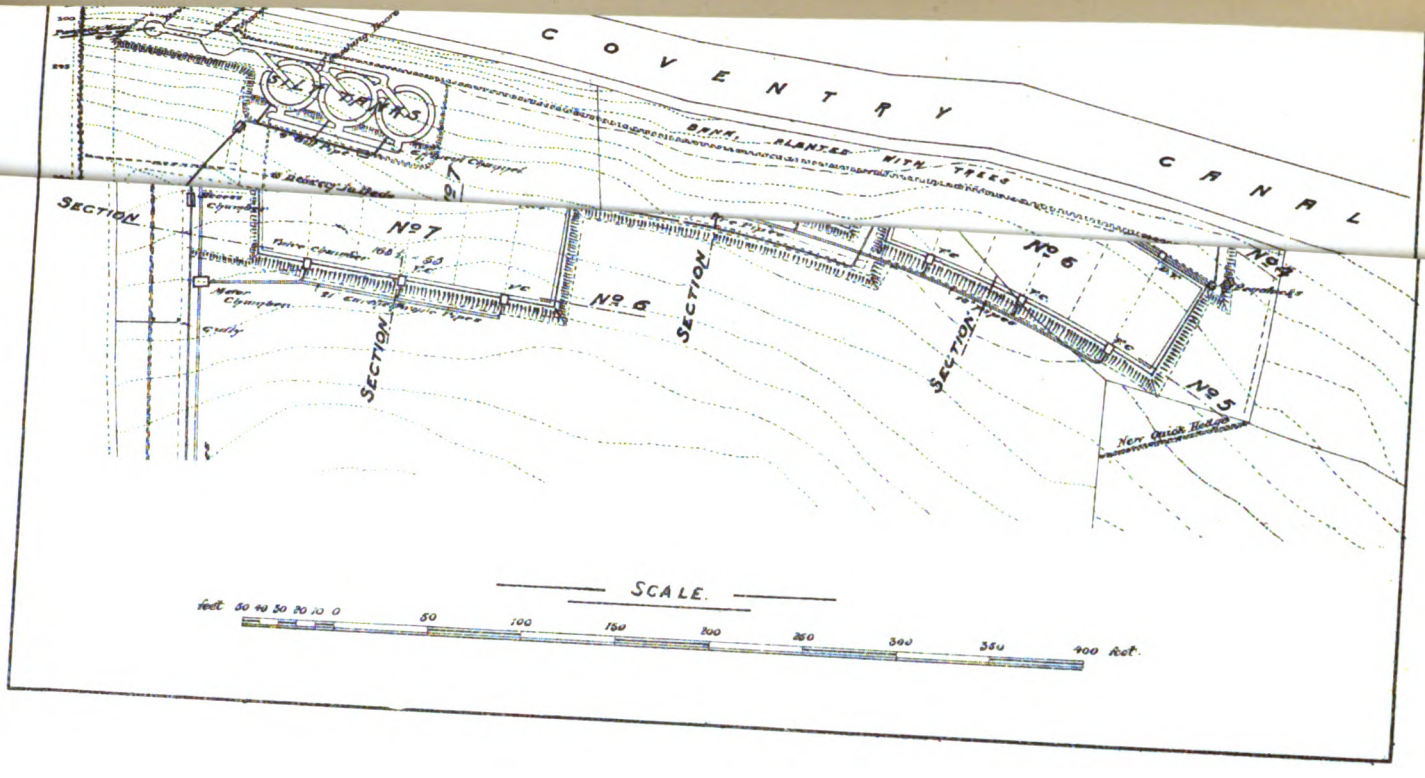

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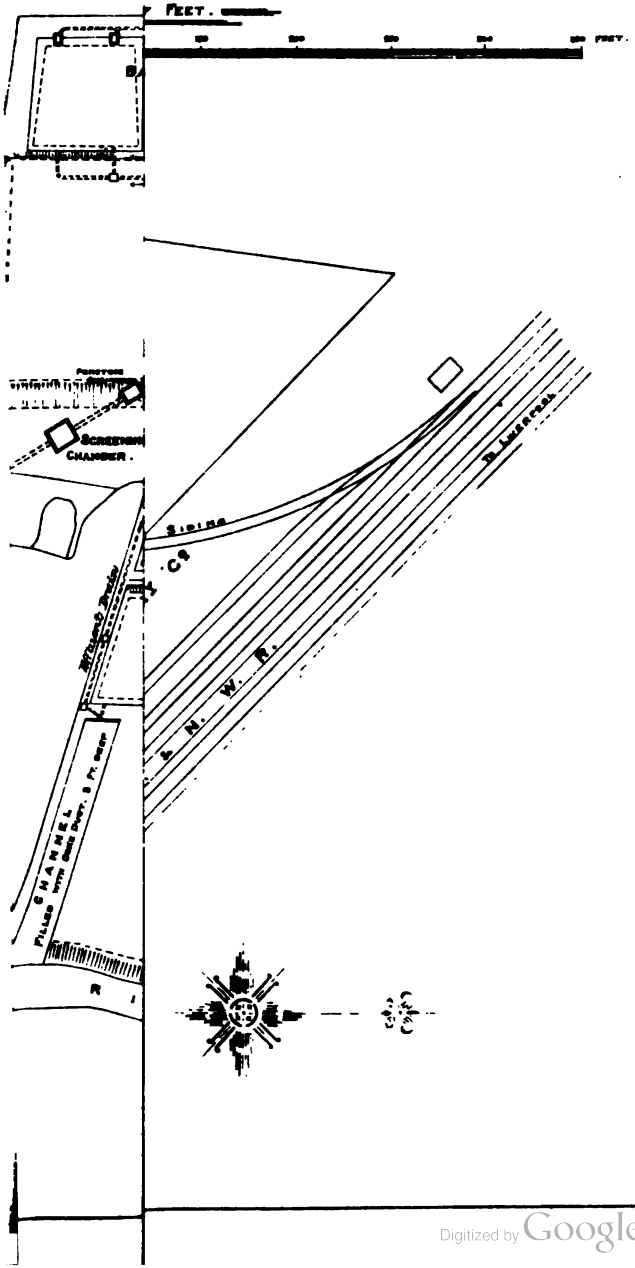

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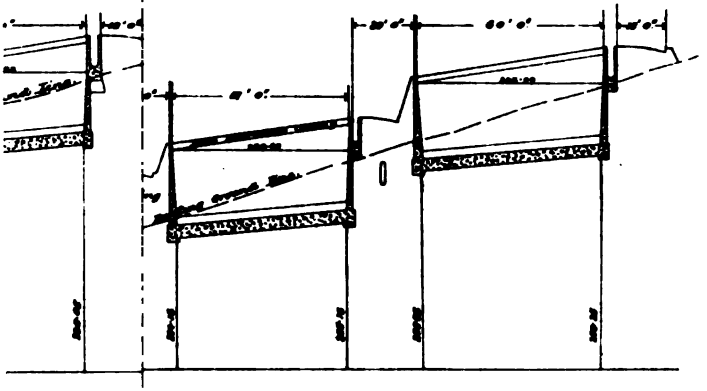

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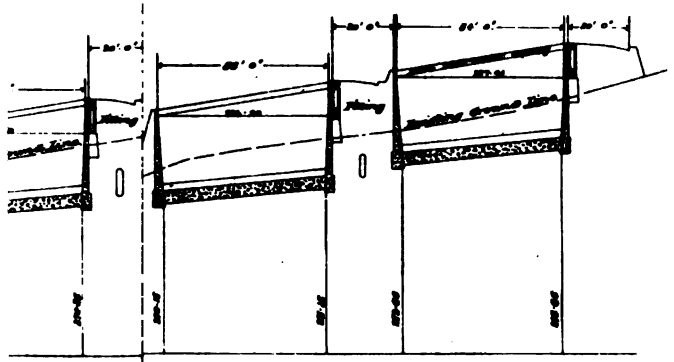

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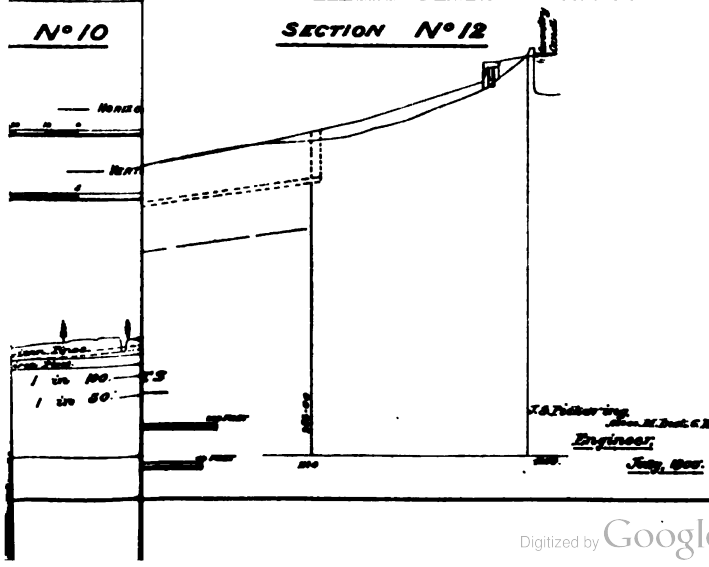

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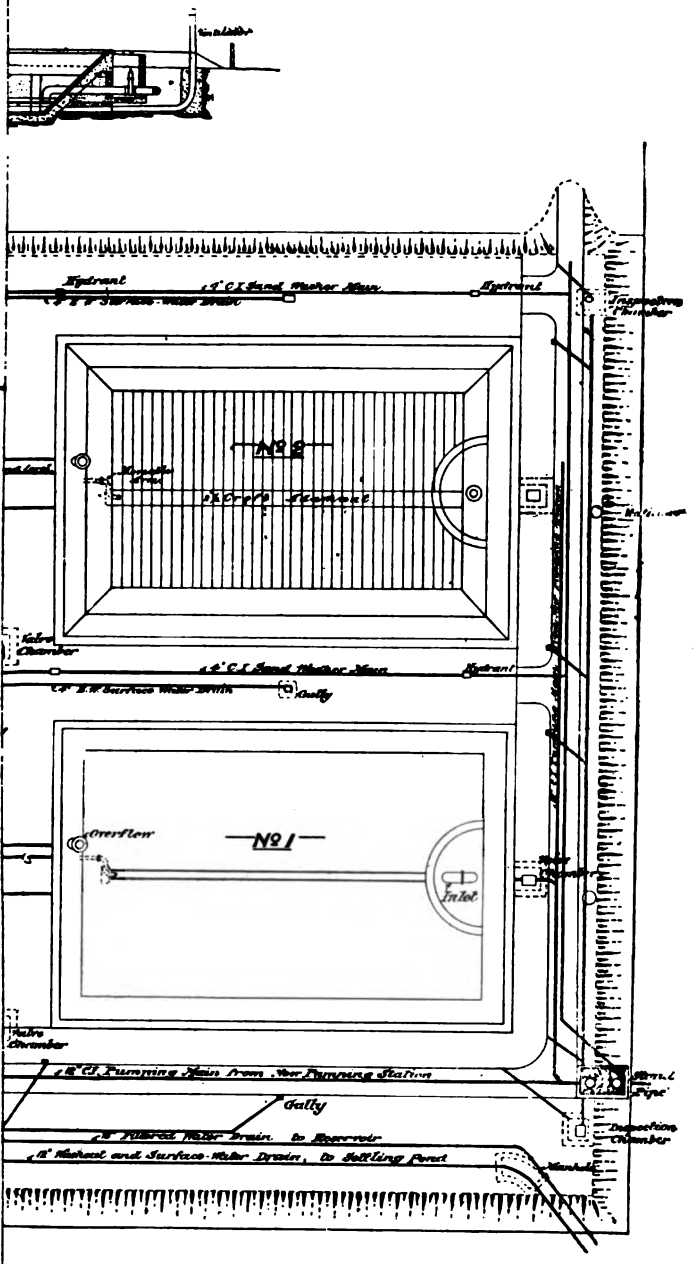

EDS AT THE WATERWORKS.

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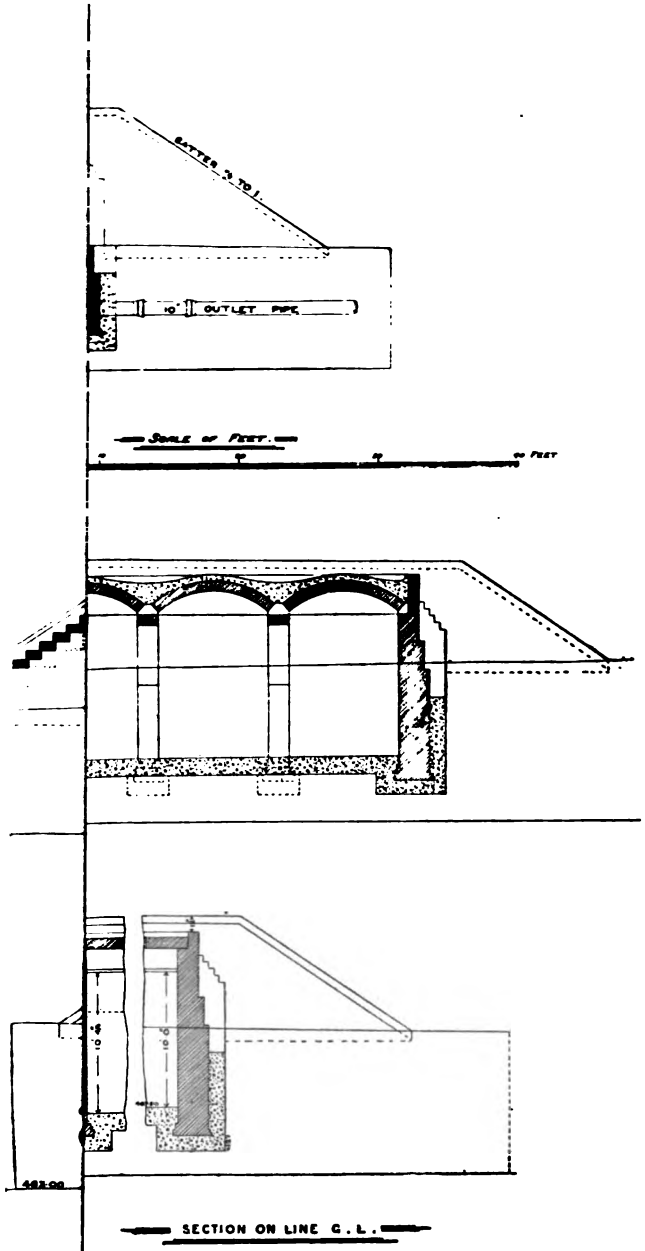

THE WATERWORKS.

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COARSE GRAIN BACTERIA BEDS (COKE)—*continued.*

Date of Reading Meter.	Register of Meter.	Decrease.	Increase.	No. of Fillings between Dates of Reading Meter.	Remarks.
No. 2.—*continued.*	Gallons.				
1901					
Jan. 30	19,000	400		100	Resting three days.
Feb. 27	18,300	700		90	
Mar. 28	17,700	600		90	
Apr. 30	17,000	700		99	
May 29	17,500		500	65	
June 29	18,200		700	67	
July 30	19,000		800	83	
Aug. 27	18,500	500		74	
No. 3.					Bed first filled Mar. 20th, 1899.
1899					
Mar. 25	24,700			12	
April 18	24,700			44	
May 27	23,600	1,100		71	
June 10	23,600			22	
July 12	23,600			53	
Aug. 9	23,500	100		81	
Sept. 26	23,500			70	
Oct. 28	23,500			57	
Nov. 16	20,900	2,600		53	
Dec. 29	20,400	500		104	
1900					
Jan. 27	20,400			62	Resting four days.
Feb. 18	20,400			42	Resting from Feb. 16th to Feb. 28th.
Mar. 28	20,300	100		68	Made up bed with coke.
April 28	18,300	2,000		79	
May 28	18,600		300	72	
June 29	19,000		400	64	
July 28	19,600		600	62	
Aug. 31	20,400		800	67	
Sept. 26	20,400			49	
Oct. 30	20,300	100		73	
Nov. 21	20,300			66	
Dec. 21	20,100	200		76	Made bed up with coke.
1901					
Jan. 31	19,600	500		100	Resting three days.
Feb. 28	18,000	1,600		90	
Mar. 29	17,500	500		91	
April 30	17,000	500		98	
May 29	17,500		500	66	
June 29	17,700		200	67	
July 31	18,000		300	86	
Aug. 28	18,000			74	

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COARSE GRAIN BACTERIA BEDS (COKE)—*continued.*

Date of Reading Meter.	Register of Meter.	Decrease.	Increase.	No. of Fillings between Dates of Reading Meter.	Remarks.
	Gallons.				
No. 4.					Bed first filled April 4th, 1899.
1899					
April 21	20,600			28	
May 30	20,200	400		73	
June 10	20,200			17	
July 14	20,200			46	Resting from June 11th to June 17th.
Aug. 8	20,200			28	
Sept. 26	20,200			72	
Oct. 28	20,200			66	
Nov. 17	18,400	1,800		55	
Dec. 29	18,200	200		103	
1900					
Jan. 27	18,100	100		62	Resting four days.
Feb. 13	18,100			42	Resting from Feb. 16th to Feb. 26th.
Mar. 30	17,900	200		73	Made up bed with coke.
April 28	17,700	200		74	
May 28	17,700			74	
June 29	17,500	200		64	
July 28	18,300		800	62	
Aug. 31	19,300		1,000	67	
Sept. 26	19,400		100	46	
Oct. 30	19,400			72	
Nov. 22	19,000	400		67	
Dec. 21	19,000			74	Made up bed with coke.
1901					
Jan. 31	18,200	800		100	Resting three days.
Feb. 26	17,600	600		82	
Mar. 29	17,300	300		100	
April 27	17,000	300		89	
May 29	17,500		500	74	
June 28	17,300	200		66	
July 31	17,500		200	87	
Aug. 28	17,300	200		74	

The following table gives the quantity of sewage dealt with and the sludge produced during the past 8 years, and 8 months of the present year.

It will be noticed from the above that during the comparatively short period of 8 years the flow has nearly doubled. The average daily quantity is now about three-quarters of a million gallons.

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Year.	Sewage Received.	Pressed Cake Produced.	Pressed Cake per Million Gallons.
	Gallons.	Tons.	Tons.
1893	139,080,000	2,768	19·9
1894	157,920,000	3,304	20·9
1895	163,286,000	3,015	18·5
1896	180,000,000	3,212	17·8
1897	192,884,000	3,487	18·1
1898	208,407,000	3,502	16·8
1899	230,181,000	2,476	10·7
1900	254,889,000	1,384	5·4
1901 .. .. .. (8 months)	180,632,000	606	3·3

The remarkable decrease in the quantity of sludge produced is due entirely to the adoption of the bacterial system of treatment.

The present sewage works have become quite inadequate to properly deal with the increasing volume of sewage, and an entirely new scheme of sewage purification is being carried out by the Author.

New Sewage Disposal Works.

The existing outfall works will be utilised as a pumping station and for the treatment of storm water. The sewage will be pumped to the new site, a distance of about 2½ miles. After screening it will pass through detritus tanks, and thence through coarse and fine grain bacteria beds, and finally purified by filtration through land. The estimated cost of the works is 45,000*l.*

The pumping engines are in duplicate, and together are capable of raising 130,000 gallons per hour. The engines are of the horizontal compound condensing type, and each engine is provided with a large surface condenser with 4-inch tubes, through which the crude sewage is pumped for condensing purposes. The pumps are of the three-throw type, the buckets being 15 inches in diameter. One set of engines and pumps has been supplied by Messrs. Goddard, Massey and Warner of Nottingham, and the other by the Worsley Mesnes Ironworks Co. of Wigan. Coal dust at 2*s.* 2*d.* per ton delivered is used under the boilers, and the cost of fuel for pumping works out at about one-tenth of a penny per 1,000 gallons raised 50 feet. The level of the engine house floor is 282 feet above Ordnance

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datum, and the highest point of delivery on the new site is 301 feet so that the pumping main has a rise of about 19 feet.

The pumping main is of cast-iron pipes, 16 inches in diameter, and is 4623 yards in length. It is laid with a rising gradient so that it can be readily emptied if desired. The main has been laid by Mr. Thos. Rowland, of Northwich, and has cost complete 9600*l.*

The new works to meet the requirements of the Local Government Board are designed to treat a million and a half gallons per day, or three times the dry weather flow. Upon the pressure in the pumping main reaching the dynamic head, due to the delivery of this volume, a relief valve will be automatically opened on the main at the old works, and the excess up to six times the dry weather flow will be made to discharge over the beds now in use, these being permanently used as storm-water filters.

Upon reaching the new site the sewage will pass through two revolving wire screens, 5 feet in width, having ¼-inch square meshes. The screens will be driven by a water-wheel propelled by the flow of sewage. The screenings will be automatically brushed from the screen and discharged into a receptacle for removal by a worm conveyer. The apparatus has been made by Messrs. John Smith & Co. of Carshalton.

Upon leaving the screening chamber the sewage will flow through three covered tanks of the "Dortmund" principle, which are each 34 feet deep and 24 feet in diameter, with a combined capacity of 150,000 gallons. These tanks are intended to intercept the heavy mineral matter which will be automatically discharged by the pressure of sewage in the tanks through a line of 9-inch pipes, 450 yards in length, to the irrigation area, where it will be delivered into furrows and deodorised with soil until it finally becomes incorporated with the land.

The site chosen for the bacteria beds is 20 acres in extent and has a natural slope of about 40 feet, thus enabling the tanks to be built in terraces. Fourteen concrete tanks are being constructed, viz.:—seven for the coarse material and seven for the fine. Each bed has an area of 1000 square yards, and as the depth of material will average 4 feet they will each contain 1333 cubic yards. Assuming the material will occupy two-thirds of the space in the beds (according to the data of the Local

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Government Board) the remaining one-third will give a capacity of 75,000 gallons to each, or 525,000 gallons to the seven beds. As they may be filled and emptied three times daily, they will be capable of dealing with a total quantity of 1,575,000 gallons per day.

From the detritus tanks the sewage will be conveyed to the coarse grain bacteria beds. Each bed is provided with three inlets and at each of these a fine screen will be placed. This special screening is rendered necessary by the large quantity of wool fibre contained in the sewage. The sewage will be distributed over the beds by means of open-jointed socketed pipes laid over the material. The material for the coarse beds will be broken granite about 2½-inch gauge. The beds will be drained by means of "U" shaped butt-ended tiles laid four feet apart.

After contact in the coarse beds the effluent will be conveyed to the fine grain beds, which will be composed of screened coke dust. This material, although somewhat finer than that generally used, has been found to answer admirably at the present outfall works.

The effluent may be applied to the fine beds in the same manner as the sewage will be applied to the coarse beds, or it may be distributed through sprays on the continuous flow principle.

From the fine grain beds the effluent will be discharged on to the land, an area of 60 acres having been acquired for this purpose.

The carriers will consist of 18-inch stoneware pipes laid below the ground, the effluent rising in chambers, at intervals of 30 to 40 yards, for distribution over the land. These pipes will work under a pressure of 4 or 5 feet, and they are being tested as laid to 10 feet head. Ewing's "Xentric" shoulder pipes are being used.

The land, which is mostly of a gravelly nature, will be under-drained to a depth of about five feet. The upper half of the sockets of the main drains are being made with a cement joint, the lower portion only being left open. The drains will be placed in the first instance about 40 yards apart, with a view, if found necessary after trial, of laying intermediate drains. Many sewage farms have been ruined by over-drainage, and the Author wishes to avoid this.

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The contract for the bacteria beds and detritus tanks is being carried out by Mr. W. Cunliffe, of Kingston-on-Thames, and the contract for the carriers and under-drainage is in the hands of Mr. Alfred Jewell, of Market Harborough.

The paper is accompanied by a series of drawings illustrating the various works described.

DISCUSSION.

Mr. J. PRICE: It gives me very great pleasure to propose a hearty vote of thanks to Mr. Pickering for the paper he has given us to day. There are one or two points in reference to streets and roads at the commencement of the paper, upon which a little further information may be useful. Mr. Pickering tells us that a tar macadam road can be made complete for about 2*s.* per superficial yard, with 3 inches of macadam as foundation, and 1½ inches of chippings as topping, including cost of materials, cartage to depôt, heating and tarring materials, scarifying road and removing old macadam, cartage from depôt, laying and steam rolling. I presume he means that the 4½ inches of macadam is the surface of the road, and has no reference to the ordinary foundation, which is quite distinct. I should like to know what special foundation is prepared for these tar macadam roads. With regard to the manufacture of concrete slabs, he evidently obtains his material from a quarry belonging to the Council, and therefore gets it very cheaply. We should like to know the cost of the concrete slabs as produced, and also the cost of the material, because the latter is an important factor. With regard to new streets, the method adopted of constructing the streets before there are any buildings put up, is one which, I regret to say, is not without the difficulties he mentions. You have a street thoroughly made up when the gas and water people come along to lay down their mains and make connections with the houses, with the result that before the street is built up you have evidence of these trenches in every direction. It is a method which I think might be altered with advantage. The method adopted at Toxteth Park was to put in the foundation of the road, the gulleys and kerbs, with a coarse coating of stone, leaving that until the buildings were erected, then we were

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able to have the foundation mended and put in proper form; the gulleys were arranged to the right level of the street, and the street finished. That method entailed very little extra cost, allowed the builders to bring their material on to the road, and gave the occupiers a certain amount of use in the road itself. Mr. Pickering makes a remark on page 86 of his paper about rolling in 5 inches of stone at one operation. I think everyone will agree that is not the right method. It damages the material, because you have the grinding action of one stone on another, and consequently you get a road which is likely to go to pieces in dry weather. The practice adopted of supplying a printed specification and type drawings, showing the construction of the streets, is one which I think might be followed by every authority. Mr. Pickering gives us the cost of new streets, including blue brick footpaths, at 50*s.* per lineal yard; but he has not given us the width of the streets, which is rather an important item. I presume he means a 12-yard road. As to house drainage, a uniform charge of 25*s.* is made for each drain connection from the main sewer to the boundary of the street. I should like to know whether the 25*s.* charged covers the whole cost or whether the local authority pay some portion of the amount. As regards public lighting, where the lamps are only lighted 3096 hours the cost of 3*l.* 1*s.* per annum seems heavy. At Toxteth Park the charge was 2*l.* 18*s.* and the lamps were lighted 3624 hours per annum. I should have thought the company would have been well paid if they had received 10 per cent. less, say somewhere about 2*l.* 15*s.* or even less. For incandescent burners an additional charge of 7*s.* 6*d.* per annum is made, but I do not know why that should be so, because we find in Birmingham, where we have over 4000 incandescent burners for public lighting, that we save 1*d.* per lamp per annum. They cost us each 2*s.* 2*d.* less for gas, and the extra cost of mantles works out at 2*s.* 1*d.* per annum. As the price charged for gas in Birmingham for public lighting is 1*s.* 1*d.* per thousand feet, whereas in Nuneaton it is 2*s.* 5½*d.*, I should expect to find a fair profit on incandescent lighting. So long as the present Act remains we shall not meet with the success we would like in the removal of privies. It is a long and laborious process to get rid of privies under the existing law, for you have to take all the local circumstances into consideration and prove that a particular privy is a nuisance to

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the neighbourhood. Having been concerned with the disappearance of privies in one town, where I reduced the number to 26, I know the difficulties which you have to encounter. The removal of house refuse weekly is a great advance. It will be found a great help from a sanitary point of view. With regard to the electricity works, I should like to know the charges for lighting and for power purposes.

Mr. R. E. W. BERRINGTON: I have very great pleasure in seconding the vote of thanks to Mr. Pickering. I do not propose to go into details, but I am very much impressed with the importance of, and the very large capital expenditure involved in, the works he has carried out. Personally, I should like to return thanks for the permission which has been granted to the Birmingham students to be present to-day, and I can say on behalf of the students we are very grateful.

Mr. N. H. DAWSON: I beg to thank Mr. Pickering for this very able paper. Mr. Pickering states in connection with the question of streets and roads, that the macadam used for repairs is machine broken at the quarry. I would like to ask Mr. Pickering's experience of machine-broken Hartshill stone, to what size it is broken, and what machine is used. Then with reference to sewerage, it is stated that an arrangement is made with the Atherstone Council to receive a portion of their sewage at 5*d.* per thousand gallons. I must congratulate the Nuneaton Council upon that arrangement, for if they take 50,000 gallons a day it means a payment of something like 380*l.* a year. With regard to public lighting, I think with Mr. Price that the charge of 3*l.* 1*s.* per lamp per annum is very heavy, considering that Nuneaton is on the border of a coal-field. At Banbury we only pay 2*l.* 13*s.* 6*d.* per lamp per annum less 2½ per cent discount. In the paragraph relating to the council offices and the fire station it is stated that electric bells are laid from the fire station to the firemen's houses. I would like to ask the cost of this, whether it was done by a local firm, the cost of maintenance, and whether, in case of change of residence on the part of a fireman, it is laid on to the new residence. I ask these questions because at Banbury the question of laying on electric bells to the residences of the firemen is under discussion. I notice Mr. Pickering says the closed septic tank has been in use for over two years and has

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not been emptied. I should like to congratulate Mr. Pickering on the working of this septic tank. He speaks of the advantage of closed septic tanks over open ones, and I agree with him on that point. At the farm, Mr. Pickering says the carriers will consist of 18-inch stoneware pipes, and that Ewing's "Xentric" shoulder pipes are being used. I would like to know what advantage these pipes have over the ordinary pipes and what is the cost.

Dr. BOSTOCK HILL: I should like to express my obligation for being permitted to attend this interesting and important meeting of this Association. In saying a few words on some of the points of the admirable paper of Mr. Pickering, I would like to congratulate him on the excellent work he does here, and also to congratulate the town on being able to avail itself of Mr. Pickering's services. I have no hesitation in saying, having been associated with Mr. Pickering in many matters connected with public works in Nuneaton—viz. some portion of of the water supply, and also experiments with the bacteriological treatment of sewage—that I have never known works more thoroughly or scientifically carried out. The question of septic tanks is one of great interest to all engaged in the treatment of sewage at the present time. I should like to point out that in dealing with sewage bacteriologically, although the sewage of Nuneaton is one of the strongest in England, it is admirably adapted for bacterial treatment. It is strong organically, as it contains the refuse from numerous manufactories, such as wool-scourers, fellmongers and the like, but the organic solids in a sewage of this character are better dissolved by bacterial means than in a weaker sewage, which often contains a good deal of inhibitory matter. Mr. Pickering says the treatment of sewage in open septic tanks cannot be carried on without nuisance, and I entirely agree with him as far as Nuneaton sewage is concerned. It contains a good deal of albuminous matter, and sulphuretted hydrogen is evolved. I do not know that I ever got a stronger whiff of sulphuretted hydrogen than on one occasion at the mouth of a septic tank when open. I also agree with Mr. Pickering in his statement that an open septic tank is not so good as a closed tank. I do not say it should be closed in the way originally suggested by Mr. Cameron, but I certainly think that a slight covering which will prevent the important action of wind on the scum will be

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useful. Although good working may result from an open tank I do think that better results are obtained by utilising both the top and bottom fermentation. Mr. Pickering calls attention to the blocking up of the beds. I think this bacteriological system of treating sewage is the system of the future, and that being so I think we must bear in mind this: if we use coarse beds and the sewage contains a fair amount of suspended matter it is absolutely certain that in time these filters will get blocked up. Engineers will have to bear in mind that not only will they lose a considerable amount of room in the coarse bed, but in time the bed will become practically useless. On this point I have carried out experiments extending over twelve months with an average town sewage, and I have found that this bed does show a tendency to block up, therefore it will be advisable to make arrangements for obviating that difficulty or for getting over it as well as possible. One other word as to the water supply. This town has had difficulty with polluted wells, and frequent outbreaks of typhoid, and then when a supply of good water was provided it was hard to persuade the people to use it owing to its yellow colour. Samples were sent to me for analysis, and I found it contained bicarbonate of iron, which gave off a slight odour, in addition to its unpleasant appearance. By a very simple process I found that this could be removed, and then it only became a question of filtration. Owing to Mr. Pickering the town of Nuneaton is supplied with a water which is free from iron, free from turbidity, and which will compare favourably with any other water in the country.

Mr. F. J. LOBLEY: I notice that Mr. Pickering says that two sewers are laid in all new streets. Can he tell me whether he has power to make the owners of houses provide dual drains for rain water and sewage, and whether he has this power by bye-laws or not. With respect to privies, has Mr. Pickering any power to prevent the erection of privies for new houses? It is very unsatisfactory when one is endeavouring to do away with privies in a district, if one has at the same time to allow new privies to be built. With regard to covered septic tanks, has there been any complaint of "blowing off" or other nuisance, and is this the reason why septic tanks are omitted in the new scheme?

Mr. J. T. EAYRS: I desire to add my meed of praise for the

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very valuable contribution Mr. Pickering has given to the Association. I have been interested in this sewage disposal scheme. I remember at the inquiry, at which there was considerable opposition, one gentleman said that this scheme had reached the "high water mark of sanitation." And I am sure you will confirm that opinion. There are one or two points which have struck me. First, with regard to the arrangement which has been made with the Atherstone District Council for receiving and treating their sewage. I think the payment of a certain sum per 1000 gallons is an unusual way of assessing the amount to be paid. As a rule these assessments are made either on the basis of population, rated tenements, or rateable value. I should like to know how the quantity is to be measured, whether by meter or a certain number of gallons per head per day. If we estimate it at 25 gallons per head per day, it would work out at a cost of something like 1*l.* per house per annum. As regards the public lighting, I agree with Mr. Price that the charge is somewhat excessive. If I remember rightly, at West Bromwich the number of hours the lamps are lighted is 4100, and the cost about 2*l.* 12*s.* 6*d.* per lamp per annum, so at Nuneaton they are paying considerably more for a less number of hours. As to incandescent gas lighting, I do not think they ought to pay more than for ordinary burners as the lessened consumption of gas fully compensates for the cost of the mantles. I think Nuneaton is to be congratulated upon having obtained a water supply which was practically found for them by somebody else who was boring with an entirely different object in view. I would like you to notice the cost of pumping water, ½*d.* per thousand gallons for a height of 300 feet. That is exceedingly cheap, but is due to the circumstance that they are situate in a coal area, and able to get their fuel at a cheap rate.

Mr. A. D. GREATOREX: I should like to ask whether the Water Department charges the Highways Department for water used for street watering and sanitary purposes. I understand it is not so. I think that is a mistake, for each department should bear its own expense, and if the Highways Department use 100*l.* worth of water for watering the streets and sanitary purposes, the Water Department should receive that sum. Having had the opportunity of seeing the drawings and the works, I congratulate Mr. Pickering heartily upon the way in which the works have been carried out. I would like to suggest to any Authority

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laying down the bacterial system the importance of fixing a good meter on the outlet of the bacteria beds, so as to take a true record of the quantity of water they will treat. My beds have now been in operation for two years, and they have been metered from the start. The coarse bed will hold 50,000 gallons; after twelve months working it had fallen to 29,450 gallons; a week ago it had further fallen to 24,600, not so large a drop in the second year, but still a diminishing quantity. The fine bed started at 45,000 gallons; a year later it had fallen to 33,337 gallons, and a week ago to 25,150 gallons. Of course it is hardly fair to regard the great loss which has taken place as a criterion, because the sewage has gone direct on to the beds. We have not had any detritus tank, and consequently a great quantity of mineral matter has gone on to the beds. My experience is that the beds go down very rapidly in the first twelve months, and then slightly; which leads me to the conclusion that after a time the working of the beds will have to be stopped, and the material taken out and re-screened. There is no doubt the bacterial system of treating sewage has come to stay. In one or two towns they have special difficulties, but I feel sure that in every town something will have to be done on the lines of bacterial treatment.

Mr. SIDNEY R. LOWCOCK: The students of the Institution of which I have the honour to be a Past-President appreciate the opportunity of being permitted to take part in this meeting. It is a very great privilege for them, and I hope they will take advantage of the suggestion which has been made and put any questions which they desire. With regard to the paper, I have to congratulate Mr. Pickering, and quite endorse all that has been said about it and his work here. I am only surprised to find there is so much important work carried out in Nuneaton. I should like to make one or two remarks with respect to the sewage scheme. I had the privilege of representing a neighbouring Authority in what Mr. Eayrs has called the very serious opposition to this scheme. The opposition was not half so serious as we could have wished. All we could say was that from our point of view it was in the wrong place, and I think I may say it was perhaps the greatest compliment we could have paid Mr. Pickering when we admitted our inability to find any fault with the scheme itself. There were two points about which I was not satisfied. First, the open tanks (for which Mr. Pickering

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I am glad to see, is now going to substitute closed tanks), and the second was the getting away of the sludge from the detritus tank, about which I am still unsatisfied. My opinion is that it will be very difficult if not impossible to make the detritus from the tanks flow along the long outlet pipe, as my experience is that it has to be taken out of the tanks with a grab or something of that sort. Then I do not like the arrangement for taking the storm water to a different place from that at which the rest of the sewage is undergoing treatment. The difficulty will, I think, be this. It is not a question of absolute quantity but of rate of flow. It is intended to pump all the sewage up to the time when it is flowing at the rate of three times the mean dry weather flow to the new disposal area. When it reaches the pumps at a greater rate than this an automatic arrangement is to divert the excess on to the storm water filter at the existing works. The result will, I think, be that if a moderate rainfall occurs at the time of minimum flow of the sewage all will be pumped to the new works and none overflow, but when the storm water reaches the pumps at or near the time of maximum sewage flow a very little storm water will cause an overflow, and the liquid passing over on to the storm water beds will be quite as bad or worse than the normal dry weather sewage and practically not storm water at all. Again, the overflows will take place at very uncertain intervals, and I should like to ask the Author how he proposes to keep the storm water beds always in a state of cultivation, ready to purify an overflow when it occurs. It appears to me it would be very much better to treat the normal sewage and also the storm water at one works and under one control.

Mr. J. E. WILLCOX: With regard to the arrangement for taking the Atherstone sewage, I would like to ask Mr. Pickering what arrangement has been made with regard to storm water. There must be a certain amount of storm water finding its way into the sewers from roofs and yards. I should like to know whether they pay on the basis of so much per head or whether by meter. Respecting open and closed septic tanks, I am inclined to disagree with Mr. Pickering when he says that no good results can be obtained from open tanks. My experience is that you can obtain equally good results from open or closed tanks. In one closed septic tank, I found difficulty from the thickness of the scum which choked the outlet pipe fixed at 18 inches

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below water or scum level and ultimately filled the whole of the tank 4 feet deep. I agree with Mr. Lowcock as to the difficulty of getting detritus from deep tanks. I have had similar difficulties and find it is impossible to get the detritus to flow as it should. But I find that these tanks can be utilised and do very good work as septic tanks.

Mr. T. R. SMITH: The paper has been very interesting to me, for the works are very similar to those we have had at work ta Kettering for three years. We have there deep precipitation tanks, bacteria beds, and finish the purification on land. We have had those deep tanks working for three years and delivering their sludge, without causing the slightest difficulty. Therefore these deep tanks, 25 feet diameter and 40 feet deep, have served us extremely well. I should like to ask Mr. Pickering how he is disposing of the sludge. I notice he is not providing presses; does he propose to deal with the whole of the sludge on the land? With a flow of half a million gallons a day we provided at Kettering 7000 yards of filter, but now that our flow has gone up to 750,000 gallons a day, I have had to point out that we have not a sufficient filtering area. I notice no open septic tank is included in the works, which is, of course, for reasons given in the paper. I notice also Mr. Pickering says that after thirteen months' working the surface of the sewage is only partially covered with scum. Previously Mr. Pickering says that the sludge is extracted in two roughing tanks, and dealt with in sludge presses. It has occurred to me that the reduction of sludge in the sewage may account for this difficulty of forming a scum. After working for nine months at Kettering with effluent from the deep tanks, and occasionally having a scum which was broken up by wind or storm, I came to the conclusion that I was carrying a lot of stuff to the filtering beds and partially choking them. I am now arranging to turn one of the old rectangular tanks into a septic tank and see if I cannot deal with the sludge in that way. As to the water-works, I think Nuneaton is to be congratulated upon dealing with so generous a company. For works which cost 70,000*l.* Kettering had to pay 128,000*l.* and other expenses have brought the cost up to 150,000*l.*

Mr. J. D. WATSON: I should like to take this opportunity of expressing my gratification at the prospect which we have in front of us to-day. The paper shows that Mr. Pickering has prepared a scheme which is bound to give satisfaction. Thanks

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to the Local Government Board, he has a very large area of land to treat his effluent upon after the bacteria beds have done a very considerable amount of purification work. In proportion to population, I have not a bigger area of land to deal with, and I do not have the bacteria beds. I should like particularly to refer to one remark Mr. Pickering makes, to the effect that the treatment of sewage in open septic tanks cannot be carried on without nuisance. I take it in that opinion Mr. Pickering refers to the sewage of Nuneaton, and so far I have nothing to say in contradiction; but it would be rather misleading to the younger Members of the Association if they were to take this dictum as being absolutely correct. I have introduced open septic tanks—liquefying tanks—in which 25,000,000 gallons of sewage are treated daily, and that large quantity has been so treated for rather more than eighteen months, and I have applied this effluent to all kinds of land. The result has given every satisfaction; whether the crops were rye grass, mangolds, cabbages, kohl rabi, etc., or whether it was applied to downward filtration beds, the results have been equally good. From some of the land which has never received anything but septic sewage we have got the best filtrant we have on the place. After passing our sewage through what we call roughing tanks—and which serve a similar purpose to the Nuneaton detritus tanks—we allow it to settle in the septic tanks for only seven hours. From those tanks the water travels in a very long 8 feet conduit, which is in point of fact a covered septic tank, so the sewage is being treated in both open and closed septic tanks; but I do not find we have any better results after the sewage has travelled three or four miles in our "closed septic tank" than we had when we applied the sewage to the land direct from the open septic tanks. But one thing I do find: when the water has got to the extreme end of our conduit the smell is much more pregnant and objectionable than at the open septic tanks. There is something in determining the proper time the water should be allowed to undergo the putrefactive process, and I am inclined, speaking for Birmingham and district, to say our sewage ought not to be treated in liquefying, resolving or septic tanks longer than twelve hours. Usually twenty-four hours is advocated, but my opinion is that twelve hours is amply sufficient, and if you go beyond twelve hours you create nuisance without obtaining corresponding benefit. With regard to

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the discussion which has taken place as to the use of open and closed septic tanks, I find the scum which is formed is nature's covering, and that is sufficient. Sometimes you do not get a perfect scum, but at other times you get it with grass growing on the top, presenting the appearance of ordinary ground.

Mr. G. W. LACEY: I wish to ask a few questions on the paper. First as to the tar macadam: Is the 3 inches which Mr. Pickering describes as foundation tarred macadam or not? With respect to the water supply, I should like to congratulate Mr. Pickering upon his arrangement for testing the water services before being used. I presume that a system of waste inspection is in operation. I would have liked to have had a definite opinion as to the preference for open or closed septic tanks, but according to the paper the closed has been used only to 50 per cent. of its capacity, while the open tanks had dealt with a daily flow equal to 150 per cent. of their capacity and consequently we can make no satisfactory comparison between them. I would also like to know the Author's opinion as to the septic tank compared with the coarse contact beds for the first treatment of the sewage. The other point I wish to refer to is the use of granite for the coarse bacteria beds. The Author also states that he finds coke to give the best results. Granite is, I presume, adopted because it is cheaper than coke.

The PRESIDENT: In my experiments I have found the open as well as the covered septic tanks extremely effective. I quite agree that it is possible to treat the sewage too long in the septic tank. I am inclined to agree with Mr. Watson that twelve hours is sufficiently long. With regard to the question of scum which has been raised, at Leicester we find we are able to protect the surface and get splendid results by means of a simple arrangement of scum boards. It is necessary to protect the surface by such an arrangement from the action of the wind.

The vote of thanks was then passed.

Mr. J. S. PICKERING, in reply, said: First of all I ask you to accept my sincere thanks for the sympathy you have extended to me owing to my unfortunate accident at Leicester. I also thank you for the very kind vote of thanks and the kind words you have said about the paper. Mr. Price referred to the foundation of the tar macadam roads. The tar macadam has been put down on old roads, and we have left the old foundation in. If we laid it on new roads we should put a thickness of 8 inches

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of foundation in. The concrete slabs we have not made very long, but roughly speaking I think we shall make them for 3*s.* a square yard. I do not think I made my paper clear as to the rolling of the stone. Mr. Price assumed we rolled it in one coat of 5 inches. We roll it in two layers of 2½ inches, which he says is the proper way. As Mr. Price assumes, the cost of 50*s.* per lineal yard is for a 12 yard road. The 25*s.* for drain connections does not quite cover the cost. It does not, however, cost many shillings over this, and we get the builders to put in an inspection chamber now that they see the advantage of it, and altogether the arrangement works very well indeed. A question has been raised as to the cost of gas for street lamps. Unfortunately we cannot please ourselves as to the amount we should pay, but probably the remarks made in the discussion will influence the gas company, particularly with respect to incandescent lighting. I think if the gas company find it will involve no loss to them they will agree to modify their charges. But the town will be competing with them shortly with the electric light, the charges for which are 5*d.* per Board of Trade unit for lighting, and 3*d.* per unit for motive power. These are the present prices, but we hope to reduce them as the works progress. Mr. Dawson asked if there was any advantage in using Hartshill machine-broken stone over hand-broken stone. We used to break all our stone by hand, but although there are advantages in having the material so treated, it is as a matter of fact, difficult to get hand-broken stone for the reason that the necessary labour is usually unavailable. For a small quantity of stone I do not think it is worth going to the expense of putting down a machine. We break to a 2½-in. gauge and use a Broadbent breaker. As to the electric bells, I am sorry I cannot give the initial cost as the Council have only just taken over the brigade. I do not think it was more than 100*l.*, and the cost of maintenance is not more than 5*l.* or 6*l.* per annum. It is the intention when a fireman leaves and another is appointed, that the bell should be connected with the new fireman's house. Mr. Dawson also asks as to the advantage of Ewing's "Xentric" pipe. The only advantage is that it allows the workmen to get the cement well into the socket under the invert of the spigot end of the pipe. The cost is only 10 per cent. more than the ordinary pipe. There is no advantage over the ordinary pipe if you can get the workmen to lay properly. As to open septic

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tanks, I cannot quite follow Mr. Watson that in some circumstances the open septic tank may not be a nuisance. Dr. Hill has given you the reasons why it must be a nuisance. As I mention in my paper, silting up of the bed will take place, but I think it will be far more economical to screen the material than to continue the chemical treatment of the sewage. In reply to Mr. Lobley, I may say that every authority has the right to lay a dual system of sewers. We do not lay a double system of drains to the house, but allow the yard and back roof water to go into the sewer. Mr. Lobley also asked if we had power to prevent the erection of privies to new houses. I am sorry to say that we have not. We have experienced no difficulty with the blowing of the tanks in the manner suggested by Mr. Lobley. Mr. Eayrs mentioned the basis on which we had agreed to take the sewage of the Atherstone authority. He said we had made very good terms, and I think so too. In arriving at the amount we estimated what it would cost the Atherstone authority to treat their own sewage, and we came to an agreement accordingly. The payment is not based upon the population, that is a very rough and ready, as well as a most unsatisfactory way of dealing with the sewage of a neighbouring authority. We deal with it for so much per thousand gallons, storm water and all. The arrangement is to measure the quantity by a tipper, which is agreeable to both parties. The tipper holds 50 gallons and discharges when full, each discharge being registered. Mr. Greatorex asked whether the water department charges for water used for watering the streets and for sanitary purposes. The water department only charges 20*l.* a year for water used for all purposes; that is much too small a sum, and later on, we shall have to adjust it. I am pleased Mr. Greatorex has mentioned the importance of a meter in connection with the bacteria system, to measure the quantity of sewage dealt with. I agree with him that it is most essential to have a meter. I would rather leave out one of the beds than dispense with a meter. If a meter is fixed on to the bed the workman knows when it begins to silt up and when to rest it, and by the exercise of care and foresight, he can minimise the silting up of the bed. Mr. Lowcock thinks we shall not be able to get the detritus to flow down the sludge pipe. I find from my experience that we can, and I am pleased to hear that Mr. Smith, of Kettering, has exactly the same experience.

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There is no difficulty in getting the detritus to flow. We have a deep tank which has not been cleared out for four years. Mr. Willcox says he can get good results from open septic tanks. What I object to in open septic tanks is not their efficiency in liquefying the sewage, but the nuisance they create in doing it. Mr. Smith asked why we are dispensing with the sludge presses. We are very pleased to dispense with them, and shall have them for sale before long. Our new works are 3 miles from the town, and with 80 acres of land we shall not require presses. Mr. Smith referred to the area of the beds. Fortunately we have plenty of room to extend when necessary. He also asked why there was no scum on the open septic tanks, and suggested that the reason was because we intercept too much of our sludge in the detritus tanks. I think that is so. In one tank where the whole of the sludge is left in there is a thick scum, and in the others there is no scum at all. It may be partly due to the rushing of the sewage through the tanks at too great a velocity. Mr. Smith referred to the generosity of the water company. There is no doubt they were exceedingly generous. The old water-works company carried out the works for the benefit of the town, the shares were largely held by one gentleman, and he made a great sacrifice in the interest of the town. In reply to Mr. Lacey, the tarred macadam is 4½ inches thick. I believe the contact bed is superior to the septic tank system. We are using granite in the bed because it is considerably cheaper than coke; it is only one-fourth or one-fifth the cost, and I believe it is a good material to use. I recognise the necessity which will arise of sifting the material, and when you come to sift the granite it will be found much more satisfactory than sifting coke as there will be no disintegration.

The PRESIDENT: On the question of open and closed septic tanks, I would like to say, where there is any risk whatever of nuisance to surrounding population you must have covered tanks, but where you have an isolated place like our Leicester farm, far away from any population, open tanks are quite sufficient.

The Members then proceeded in brakes to the extensive tile, pipe, terra-cotta and brick works of Messrs. Stanley Bros., Ltd., where the whole of the manufacturing departments were thrown open for inspection. At the conclusion of the inspection the

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Members were entertained to luncheon. Mr. Stanley presided. The afternoon was devoted to an inspection of the new sewage works at Hartshill, in course of construction, for the treatment of sewage on the bacteriological system. On returning to Nuneaton a visit was made to the electric light station, and the proceedings of a most successful District Meeting were brought to a pleasant termination by Mr. and Mrs. Pickering entertaining the Members to tea in the Assembly Room in which the business proceedings had been transacted earlier in the day.

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DISTRICT MEETING AT BIRMINGHAM.

April 5, 1902.

Held at the Council House, Birmingham.

E. GEO. MAWBEY, M. INST. C.E., PRESIDENT, *in the Chair.*

THE Deputy Lord Mayor (Alderman S. Edwards) heartily welcomed the Members to Birmingham. He was sure all present would regret to learn that the Lord Mayor was unable to attend through illness.

The President returned thanks on behalf of the Association.

Mr. J. Price (Birmingham) brought before the Meeting the claims of the Orphan Fund of the Association, and trusted that those Members who did not at that time support this most worthy object would do so henceforth.

The Minutes of the last District Meeting were read, confirmed and signed, and the following papers were then read and discussed.

THE FILTRATION OF RIVER WATER.

BY ALFRED J. JENKINS, ASSOC. M. INST. C.E.,
DEPUTY BOROUGH ENGINEER, BURTON-ON-TRENT.

THE purity of our water supplies is a subject which naturally attracts the attention of all who are associated with Municipal Government, and as the responsibility of preserving it falls upon the engineer in charge, it is a subject well worthy of consideration by this Association, which embraces so many

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who are engaged in the design and in the management of water-works undertakings.

There are, of course, many districts which are in the happy position of being blest with water supplies quite free from impurities; there are, on the other hand, many in which the very greatest care has to be exercised for the elimination of polluting matter; and there are also some which put up with supplies which are open to the gravest suspicion, and which might be very considerably improved by the installation of proper methods of purification.

As our large industrial centres are filling up, the pressing demands for increased supplies have to be met, and as it is not practicable for every place to appropriate a lake in Cumberland or a valley in Wales, consideration has to be given to the utilisation of the less pure streams and rivers, and to the means available for restoring them to something like the purity of their upper reaches.

Since the passing of the Rivers Pollution Prevention Act of 1876, very much has been done, more especially in the last few years, to mitigate the horrible pollution that has been poured into nearly all our finest rivers, but much still remains to be done, and municipal engineers, more than any others, appreciate the hopelessness of ever being able to keep all pollution from rivers, which flow through, and, therefore, drain our more populous districts.

The question then arises as to whether rivers, which are liable to pollution, can be regarded as possible sources of water supply, and, if so, what means are necessary to prevent such a supply becoming dangerous to the health of the community.

The use, for public water supplies, of rivers liable to considerable pollution, has fallen into great disrepute in consequence of the danger attendant thereon, and though the Hamburg cholera epidemic of 1892, which resulted in something like 8000 deaths in one month, probably stands alone, yet in American cities, which for the most part consume unfiltered river water, the prevalence of typhoid fever greatly exceeds in the average that of the whole of Europe.

This is indisputably due to their comparative neglect of sand filtration, a process which has been in use in England for over seventy years with highly beneficial results; but it is only within the last few years that the development of the study of

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bacteriology has given us an explanation of why such good results have been obtained, and enabled us to lay down rules for the scientific working of the process.

The introduction of filtration in 1829 by James Simpson on the works of the Chelsea Water Company, aimed at nothing more than the clarification of the Thames water from the matter in suspension, and for many years the only standard of purity recognised, was the physical aspect of the water and those properties which immediately affected the senses.

That the desired result was obtained, is an undoubted fact, and was duly recognised, though it was very many years before it was observed that other results were being obtained, and that chemical changes were taking place in the water submitted to filtration; on examination of which interesting comparisons could be made, and the efficiency of the filters carefully regulated.

It was the investigations of Koch, and other eminent bacteriologists who considerably advanced our knowledge on this subject, that gave us the true explanation of the changes that actually do occur in the purification of water, and suggested means by which reliable tests can be made of the manner in which the methods of purification are working.

In considering the question of the purification of a particular river water, the engineer has not to use stereotyped rules in dealing with every case in a similar manner; but he has to consider the degree of impurity of the water in question and the uses to which it has to be put, together also with the practicable means available, and the expenditure which is permissible; it is a matter of regret that the latter point is one of some considerable importance, and it is unfortunate that the question of water supply has only recently begun to be recognised as one of national importance, and that unreasonable cost is often thrown upon poor authorities whose geographical positions place them in considerable difficulty.

It is not possible for the Author to deal with varieties of circumstances within the limits of this paper, but he will presume that a river liable to serious pollution has to be purified in the highest degree for domestic consumption, and that reasonable cost is permissible and that the best of materials are available.

It has now been proved beyond all possibility of contradic-

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tion that typhoid fever and cholera are water-borne diseases, and neglect of precautions may lead to terrible results, as has been borne to our memory by the calamities of Hamburg, Worthing and Maidstone.

The consideration of the purity of water is one of extreme complexity, and it is not satisfactory to say that because a water contains less than a certain standard of chlorine, ammonia, nitrates and so on, that it is fit for domestic consumption; neither is it possible to condemn a water because it contains certain of those matters in excess. The whole history of the water must, if possible, be traced out, and, in conjunction with the chemist, the geologist and the bacteriologist must be consulted.

The chemist can certainly tell us that a water is probably quite pure, but he cannot definitely say that it is so; the geologist can help us by saying whether the salts present in solution may have been taken up from mineral deposits; the bacteriologist can tell us whether bacterial life is present in any marked degree, but he too can only speak as to probabilities, because the science has not yet sufficiently advanced for it to be possible to unerringly detect the presence of harmful bacteria.

The universally accepted bacteriological standard of purity is 100 bacteria per cubic centimetre; that means, that if a cubic centimetre of water be cultivated it should produce not more than 100 colonies which can be counted.

When we begin to talk of hundreds and even thousands of bacteria per cubic centimetre we are getting into very alarming figures; but it must not be thought that all these bacteria are pathogenic or harmful, indeed by far the largest proportion are non-pathogenic; nor must it be understood that because a bacteriologist examines a water and finds no pathogenic bacteria in it, that that particular water is fit for drinking purposes. "It is obvious that the specific bacteria of typhoid and cholera must be very widely scattered in any water which can by any stretch of imagination be called potable, so that if we should ever become possessed of methods which would unerringly detect these forms in such a volume of water as can reasonably be submitted to examination, their non-discovery would possess absolutely no value in establishing the harmlessness of the water in question." *

We believe, however, that if a water is liable to organic

* Professor P. Frankland.

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pollution and contains a large number of bacteria, some of them will be pathogenic, and that if we reduce the total number of bacteria, as we can do by some 98 per cent. or thereabouts, it is reasonable to suppose that we can also reduce the number of pathogenic bacteria in about the same proportion.

It is now customary in the large cities of Germany, Belgium and America, to rely upon such investigations for information regarding the working of their water filters. As an instance of the care that is necessary in watching the filtration of a highly polluted supply, it may be mentioned that at Antwerp, it is customary to make on the average some 600 bacteriological examinations per month.

Those who have seen the filthy condition of the Antwerp water before filtration will appreciate the necessity for this great precaution, and it is an excellent example of a highly polluted water being converted into a very satisfactory domestic supply.

These methods are now applied to the examination of London water, and of 216 samples of filtered water supplied to London and examined bacteriologically during a recent month, all were found to be well filtered.

Having said so much as to the standards of purity, it will now be well to consider the means to be adopted for the treatment of raw water, and to put it into such a condition that the accepted standard may be maintained.

The means taken to reduce the number of bacteria present will, with one exception, which will be hereinafter referred to, be the best means possible for the elimination of the mineral matter and vegetable and insect life present.

In the treatment of river waters, there are three methods :—

1. Sedimentation in storage reservoirs.

2. Slow filtration through sand, with which we are most familiar in England.

3. Coagulation by the addition of chemicals and the subsequent rapid filtration, which is largely adopted in the United States of America.

The first of these is frequently used in conjunction with either of the others.

The advantages of sedimentation cannot be too highly advocated. A few days' rest will effect the clarification of river waters containing all but the finest of particles, and the deposit of mineral matter in suspension is accompanied by a very great

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reduction of the bacteria present. Dr. Frankland has published the following figures in relation to some of his investigations in 1892 of portions of the London water supply.

In the case of samples taken from the West Middlesex Works at Barnes :—

Unfiltered Thames water from Hampton	1437 bacteria per c.c.
Unfiltered Thames water after passing through one subsiding reservoir	318
Ditto—two subsiding reservoirs	177
A reduction of	88 per cent.

New River Water-Works, Stoke Newington :—

New River cut above reservoir	667 bacteria per c.c.
Outlet of first reservoir	560
Ditto—second ditto	183
A reduction of	72 per cent.

Apart from the reduction of the number of bacteria by what we may term precipitation due to the mechanical sedimentation of the mineral matter, there is no doubt a great reduction in the number and vitality of the harmful bacteria by the bactericidal action of the harmless species working with the assistance of sunlight and air, and it may safely be assumed that the longer the period allowed for sedimentation, the greater the degree of purity that will result. It is not usual, however, to pay much attention to the bacteriological side of the question at this stage of the purification, but rather to consider the question of amount of storage necessary for the reduction of turbidity and the maintenance of a continuous supply.

The amount of storage necessary to clarify any particular water can only be determined by experiment, it being wholly dependent upon the nature of the matter in suspension; but it is generally conceded that the longer the period allowed for sedimentation the better; the deposit of the coarser materials will greatly facilitate the subsequent filtration if only regarded from a mechanical point of view, and it will moreover immensely reduce the cost of cleaning filters.

So fine is the mud of some of the American rivers, such as the Mississippi, consisting as it does of the finest alumina silt, that, having regard to the immense storage capacity that would be required to permit effective sedimentation, the Coagulation Method (to be afterwards described) has to be adopted.

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Slow Sand Filtration.

Filtration is merely the straining of water through fine insoluble media, and nothing is, of course, more suitable than clean fine sand.

The flow of water being continuous, the filter first becomes clogged in its upper layers by those coarser particles present in the water, which are larger than the interstices between the sand grains. This, of course, reduces considerably the amount of intersticial space and consequently the finer particles present in the water are intercepted. This process goes on until the bacteria are also intercepted in ever increasing numbers until the time arrives when the filter becomes blocked and scraping off the top layer has to be resorted to.

As the result of careful observation, it has been found that if a high degree of bacterial efficiency is to be maintained the rate of filtration must not exceed 4 lineal inches per hour; this is practically 2 gallons per square foot per hour or rather more than 1 million gallons per acre per twenty-four hours. It is highly essential that this rate of filtration be regular and controlled in such a manner that it cannot possibly be exceeded, or the effect will be to wash the bacteria previously caught on the upper layers of the sand into the coarser materials below, or through the filter altogether. The mechanical methods to be applied will be referred to later. It must also be noted that in starting or re-starting a filter after cleansing a much lower rate of filtration should be used.

It is hardly necessary to go into the question of construction of the walls and floor required, or to point out the necessity of their being of substantial design and good workmanship, thoroughly water-tight in every part; but the depth necessary is of importance: from 7 feet to 8 feet 6 inches is usually regarded as the correct depth, but the writer prefers the greater depth divided up as follows:—

2-feet between the top of the wall and surface of water (in very large filters it should be more, in very small ones it may be less); 2 feet between surface of water and top of sand—this depth being necessary to prevent the water becoming unduly heated in summer, and to prevent the possibility of damage to the surface of the sand by ice in winter. In America 4 feet of water on the sand is found necessary, and in the Northern

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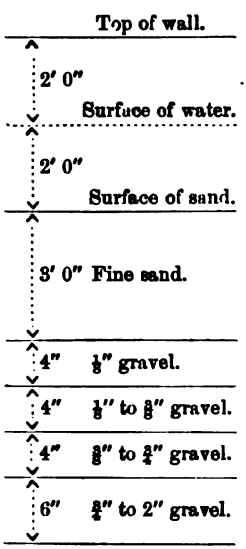
States and in Germany many filters are covered over. As filtering medium 3 feet of fine sand, and below it 1 foot 6 inches of fine to coarse gravel, arranged as follows (beginning at the top): 4 inches of gravel, that will pass through a sieve with one-eighth of an inch holes, 4 inches of gravel that was rejected by the last named sieve but passed through one with three-eighths of an inch holes; thirdly, 4 inches of coarse gravel retained on the three-eighths sieve, but passed through a three-quarter inch sieve; below this about 6 inches of three-quarter inch to two inch gravel or broken stone, in or below which are laid drain tiles to a central drain. The floor of the filter should slope quickly to the central drain, as a free outlet from all parts of the bed is of the highest importance to promote equal filtration throughout its full area. The drains should be in such a form that the filtered water is collected thoroughly and evenly, and so that when charging the filter from below the water is distributed without risk of disturbing the sand. The ends of a number of the drains should be connected to ventilating pipes run up in the walls. The size of the sand grains has been a matter of much contention; it is of importance that they should be uniform in size, and as fine as can be obtained. The Author has used sand so fine that over 60·0 per cent. of the particles would pass through a sieve of 4900 meshes to the square inch, and the filters are giving excellent results. It was considered necessary to put under this fine sand a 6-inch layer of rather coarser sand to prevent it being washed away. There is no doubt that with 4 or 5 feet of sand of a grain one-hundredth to one-eightieth of an inch diameter, after the sand has been used for some time a rate of filtration of 4 gallons per square foot per hour may be used, but such fine sand is not always obtainable, and it is therefore advisable to keep to the slower rate of working.



With a depth of sand of 3 feet only, scraping for the purpose of cleaning, which reduces the thickness by about ½ inch on each occasion, should not be continued for more than a foot in depth;

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2 feet of sand must be the minimum remaining, and if the source is a polluted one, a greater depth is preferable, because at times the surface of the sand gets broken and it is only by a great depth of sand that bad filtration can be avoided. The greater the depth of sand, the more support there is for the surface layer of slime, which is the most useful part of the filter bed.

It is pretty generally known that a filter composed of entirely new and sterile sand is, when started to work for the first time, a very dismal failure. Even if the sand has been most carefully washed before being placed in the bed, the first result is that the water leaves the filter of a worse appearance than when it entered it. After a few days (sometimes as few as seven), a decided improvement becomes apparent, and, in the case of an average water, three weeks produces a perfect effluent at maximum speed.

The danger of reducing the depth of fine sand in the filter is clearly set forth in the diagram, Fig. 1, which indicates the

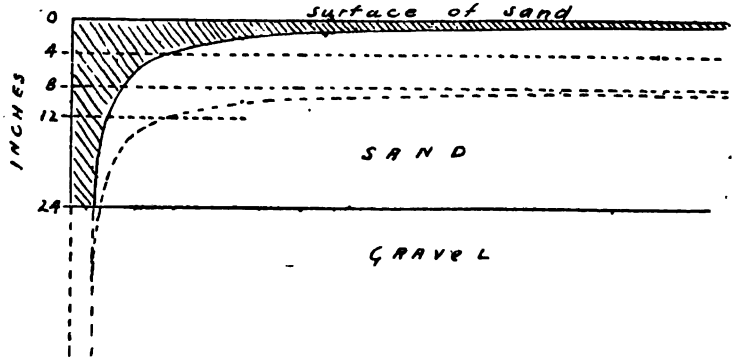

FIG. 1.—The hatched portion of the diagram indicates the comparative number and disposition of the bacteria in 24 inches of sand filter. The curved dotted line shows the position of the hatched portion if lowered 8 inches, indicating an increase in the number of bacteria below the original 24-inch depth.

comparative density of bacteria which have been intercepted by the filter.

From this it will be seen that the number of bacteria is reduced until the water has passed through 24 inches of sand, after which the number remains practically constant; it follows, therefore, that to obtain the best results we should have not less

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than two feet of sand when working, of course at the rate of four inches per hour.

As before mentioned, after working for some time the density of deposit upon the surface of the filter has become so great that to overcome the resistance to the free passage of water, either an increased pressure on the filter must be employed or the obstructing matter removed. Recourse is often had to the former, as it is not always convenient to perform the latter operation, and therein lies a considerable danger, for, if the pressure on the surface be increased unduly, there will result a cracking in the surface accumulation of silt through which water will pour with increased velocity washing away millions of bacteria off the surface of the sand grains.

In the case of the Berlin filters, the maximum head allowable has been fixed at 2·62 feet, and about the same figure has been adopted in most English filters.

It is not sufficient that the outlet from a filter-bed should be merely controlled by a sluice valve; under such conditions it is absolutely impossible to ascertain what the head on the filter is, or whether the safe head is being exceeded. A very good arrangement is that shown in Fig. 2, which may be briefly

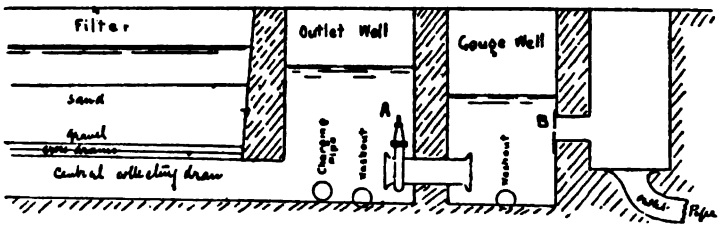

FIG. 2.

described as follows. The water level in the filter-bed is maintained at a constant level by means of an automatic valve at the inlet, the water passes through the sand and gravel to an outlet well, the water level in the outlet well will be lower than that in the filter, owing to the frictional resistance of the filter; when the filter is clean it will not exceed two or three inches, and it must never exceed two and two-thirds feet; the sluice valve A gives admission to the gauge well, which, at the point B contains a submerged orifice in a thin metal plate; by controlling the valve A, the water level in the gauge well must be maintained

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at a constant level to give a discharge through the submerged orifice, according to the area of the filter and the rate of filtration determined upon. This level is ascertained by means of a float, and once determined upon, it will remain constant; the difference in level between the water level in the gauge well and the water level in the filter will, of course, be the two and two-thirds feet if that figure be adopted as the greatest head allowed on the sand. The difference in level between the outlet well and the gauge well is that due to the frictional resistance of the valve A.

Following out the working of this arrangement in another way, and remembering that the water level of the filter is always constant, then if the filter be clean the water-level in the outlet well will be only a few inches below it, and to maintain the constant level in the gauge well the valve A must be opened a few turns until the water-level in the gauge well rises to the proper height above the gauging orifice; as the filter bed becomes clogged the water-level in the outlet well will fall, and to maintain the proper level in the gauge well the valve A must be further opened, until eventually it is fully opened and the water-level in the two wells is the same. Beyond this point it will not be possible to maintain the head on the submerged orifice and the filter will be doing less than its required work; as it is impossible to exceed the pre-determined head of two and two-thirds feet, the only alternative is to clean the filter by scraping off the top layer of sand, for which purpose the working of the filter must be temporarily suspended.

The outlet and gauge wells should each be provided with wash-out pipes for the purpose of draining them, and an inlet pipe for charging the filter with filtered water from an adjoining bed.

The design of the inlet chamber has not yet been referred to; the chief points to be regarded are: (1) Regulation of the rate of inflow so as to maintain a constant top water level; (2) arrangement so that the inflow of water shall not unduly disturb the sand around it. To meet the former requirement, a good automatic valve is necessary, and for the latter it is well to make the inlet basin fairly large, direct the inflow downwards so that it may eventually flow upwards and out of the basin with decreased velocity. It is also well to keep the wall of the inlet chamber above the sand level.

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When the bed is in working order the inlet valve must never be opened until the filter has been filled to well above the top of this wall with filtered water from below.

In cleaning a filter it is not necessary to remove any large quantity of sand; in fact, the object should be to remove as little as practicable.

The operation is usually performed by carefully skimming off half an inch by means of shovels, and removing it to a convenient depôt. On re-starting the filter there is an absence of efficiency, due to the comparative coarseness of the top layer, and filtration should be conducted slowly; with some river waters it may be possible to use the water after twenty-four hours, but seldom should the normal speed be reached before the filter has been in use for three or four days. The object of filling from below is to gradually drive the air out and to prevent damage to the crust of the sand by air breaking through in large bubbles, which occurs if the filter is filled from above; so slowly should the operation be conducted that some eight or ten hours are necessary.

The washing of sand presents very considerable difficulty, and is a question which frequently bothers the engineer. There are several types of machines in use, including small boxes in which from half a cubic yard to a yard of sand is washed by the upward flow of water. These are not altogether satisfactory, owing to the immense amount of labour entailed in filling and emptying them. A more mechanical method is based on the principle of a revolving horizontal cylinder, along which the sand is forced in one direction with a current of water introduced to flow in the opposite direction, and the speed so adjusted that the sand leaves the cylinder quite clean. It is sometimes advisable to wash sand immediately it is removed from the filter, otherwise vegetable spores germinate and grow. It is sometimes found where such are absent that sand washes better if allowed to stand for a month or two exposed to the cleansing action of the sun and air. The sand removed at each cleansing even when immediately washed is not then replaced, but the scraping is continued until the permitted minimum depth of sand is reached, after which the filter is restored to its original form. The washing of sand in boxes fixed in the filter-bed itself is objectionable because it keeps the filter idle during a long and tedious process.

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Cost of Filters and the Cost of Working.

So much depends upon local conditions that no definite sum can be put down for the cost of construction of works, and working expenses are also so dependent upon the condition of the raw water to be treated that they are far from uniform. It may however be interesting to state that the average cost of a large number of works, scattered over the whole of northern Europe, has been about 10,000*l.* per acre for uncovered, and 15,000*l.* for covered filters, and at this figure first-class work can be carried out in England at the present time. In the United States the average cost has been 30,000 dollars per acre for uncovered filters, and about half more for covered. These figures are exclusive of reservoirs and sedimentation basins.

The average cost of working the filters of the seven London water companies for fifteen years has been stated by Mr. W. B. Bryan, Engineer of the East London Water Company, to be slightly over 4*s.* per million gallons, the minimum being 3*s.* for the Chelsea Company, and the maximum 4*s.* 9*d.* for the Grand Junction and West Middlesex Companies. In Germany, where more turbid water has to be dealt with, the cost is higher. This of course includes all labour, sand-washing and supplies for the filters.

The Treatment of Turbid Waters.

Reference has already been made to the use of sedimentation tanks or reservoirs preparatory to filtration. Under certain conditions this useful preliminary is not always practicable; for instance, when land of sufficient area is not available, or when the amount of storage room necessary would be out of question owing to the length of time required for the effective sedimentation of a very fine alumina silt, such as is found in many of the American rivers.

An attempt to pass turbid waters through sand filters without some preliminary treatment results in the very rapid clogging of the filter, or if the silt be a very fine one turbidity will still remain. The conditions which prevent the passage of the fine suspended particles through sand filters are similar in a general way to the conditions which control the removal of bacteria. But it is perfectly possible to filter a certain water with excellent bacterial result, and to still have a turbid effluent, because some rivers contain mineral particles which are smaller than bacteria,

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and, moreover, bacteria probably have a power of adhering to the sand grains much in excess of that possessed by the clay particles; on the other hand it does not necessarily follow that because a filter can reduce the turbidity of a water that it is effectively reducing the number of bacteria.

The American method of dealing with turbidity (which by-the-bye is much in use in Europe also) consists of the addition to the raw water of a precipitant, or, as it is generally known over there, a coagulent, such as lime or sulphate of alumina, which forms an inorganic precipitate in the water, the presence of which causes an aggregation to take place of the fine particles in suspension; these by their combined weight more readily find their way to the bottom of the tank or pond, in which the water must be allowed to stand some time, unless indeed the action be allowed to take place in a filter, when the current of water quickly carries the precipitate to the sand, where it is arrested.

The coagulent in most general use is alum; this salt forms a gelatinous precipitate which quickly aggregates the fine suspended particles present in the water, including the bacteria, and allows them to be more easily removed by filtration than would otherwise be the case. In addition the alumina has a chemical affinity for dissolved organic matter, and the chemical purification may be more complete at very high rates than would be possible with sand filtration without coagulation at any rate however low. Waters stained yellow or brown by contact with peat, which cannot be in the least degree altered in colour by sand filtration alone, can by the coagulation method be effectively dealt with.

Lime may with advantage be used as the coagulent in certain cases, where it may also serve a second purpose, such as in the softening process sometimes required, or for the neutralisation of acid water, which is capable of taking up lead from service pipes.

The amount of coagulent to be used must in each case be carefully studied, an insufficient quantity will be useless, an excess would be useless waste, and, in the case of alum, would be dangerous to the purity of the water. This last point is one of the chief arguments of the enemies of the system, and undoubtedly it is an objection; but there is a big margin of safety, and in all cases of purification of water for domestic consumption supervision must be so complete that carelessness in working is quite eliminated.

For information upon the amount of coagulents necessary, and indeed upon all other points in filtration, the Author can

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refer to no better work than that of 'The Filtration of Public Water Supplies,' by Allen Hazen.

Mechanical Filters.

This term has been applied to filters of a particular class which deal with water at a much greater rate than the slow sand filters already described; in fact, something like 50 to 100 times the amount of water per unit of surface area is passed through a mechanical filter as through the other type. As already stated sand filters are mechanical in their methods of operation, but when the term is applied to filters it is meant to indicate that a distinct type is referred to which requires a great amount of manipulation and attention.

This class of filter has been very extensively used in the United States, and the reasons for its adoption include:—

1. Small first cost.
2. Efficiency in dealing with muddy waters.

The causes which have probably prevented their general adoption in England are:—

1. Heavy working cost.
2. The success of the older methods and our insular prejudice to innovations.

Comparing the two systems and considering working cost against first cost, there is practically no difference between the two.

Furthermore, it has been shown that as high a bacterial efficiency can be obtained with the newer method as with the older; but there is no doubt that it requires constant supervision in the highest degree; the risks of accidental interference are infinitely greater, and therefore the risks to health are much increased.

The construction of a mechanical filter is usually as follows:

A cylindrical vessel, probably of iron, partially filled with sand of uniform grain and considerably coarser than in use in slow filters; this sand rests upon a perforated plate, and provision is made that it will not be washed away.

The rate of filtration being so greatly in excess of four inches per hour, this filter would of itself be useless to prevent the passage of bacteria, so that it is almost invariably used in conjunction with the coagulation method already described.

The alumina compound (a sulphate) re-acts with the carbonates of lime and magnesia contained in the water (if these are absent in the raw water, carbonates must be added as a pre-

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liminary to the treatment), and is precipitated as alumina hydroxide, a magma of gelatinous appearance and quite insoluble in water:—

$$\underset{\text{(Alum)}}{K_2Al_2(SO_4)_4} + 3\underset{\left(\substack{\text{Carbonate}\\\text{of lime}}\right)}{CaCO_3} + \underset{\text{(Water)}}{3H_2O} = \underset{\left(\substack{\text{Sulphate}\\\text{of lime}}\right)}{3CaSO_4} + \underset{\left(\substack{\text{Sulphate}\\\text{of potash}}\right)}{K_2SO_4} + \underset{\left(\substack{\text{Carbonic}\\\text{acid gas}}\right)}{3CO_2} + \underset{\left(\substack{\text{Alumina}\\\text{hydroxide}}\right)}{Al_2(OH)_6}$$

This material falling to the bottom of the water mechanically entangles all suspended matter and bacteria, and is deposited in a layer upon the surface of the sand filter, so producing in a few minutes the real filtering medium, which in the slow sand filter is only produced after many days.

Until the deposit is sufficiently great to give bacterial efficiency the filtrate must be wasted. After a comparatively short time, varying as in the sand filter with the turbidity of the water, the deposit becomes so great that its removal is necessary; this is done by introducing a reverse current of filtered water, the sand meanwhile being stirred up with rakes. The washing can be accomplished in about 15 minutes, and at an expenditure of filtered water which need not exceed five per cent. of the quantity passed through the filter since the previous washing; but with very muddy waters more is required, and in an exceptional case at Louisville the amount sometimes reaches 30 per cent.

Apart from the quick formation of an artificial "bacterial felt" a further action of the precipitated alumina hydroxide is to unite with the dissolved colouring matters of tinged or stained waters, removing them and producing a clear and sparkling product, which cannot be arrived at by the English system.

It has been demonstrated that high bacterial efficiency can be obtained with this class of filter even in the absence of turbidity, but it is dependent principally upon the amount of sulphate of alumina used.

In very large plants it has not been usual to have very large individual filters, but rather to have a very large number of them, a battery of 20 or more being by no means an exceptional size.

From the complexity of mechanical filters, it will be understood that the supervision necessary to obtain uniform efficiency, with a large plant, must be very perfect. In fact, it is quite evident that there is little chance of working such a plant without frequent "accidents." This must be a serious objection to the adoption of mechanical filters with waters liable to serious pollution and required for domestic consumption.

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Double Filtration.

The Puech system of filtration, which is a modification of the slow sand method, has recently met with much favourable comment. The idea is to introduce a preliminary roughing filter, by means of which the coarser materials in suspension are intercepted with the result that the slow sand filters do not require scraping so frequently, thereby saving a great amount of labour, and the time otherwise lost in ripening the beds. This system is in use in Paris and elsewhere, and it is stated that the slow filters will run three or four times longer without scraping.

The Grand Junction Company have used double filtration with much success, two separate systems of filters at different levels being provided.

At Bremen and Altona the filters are all on the same level, but the water, in each case a highly polluted one, is passed first through a recently cleaned bed (thereby supplying the bed quickly with the ripening materials) and then through a ripe bed, which is certain to give high bacterial efficiency. In both towns the results obtained are exceptionally good.

Other systems of filtration include the Fischer and Maignen systems, but it is difficult to see that the excessive cost results in any considerable efficiency.

The Author has attempted to describe methods adaptable to the purification of very polluted waters; it does not follow that because a bacterial efficiency of over 98 per cent. is necessary with water from the Elbe or Scheldt that it is required with that from the upper reaches of such rivers as the Severn or Dee. In such cases as these filtration is a very different matter, and probably only means the straining out of the fish, insect and vegetable life; but between such extreme cases as those referred to there exists probably almost every grade of water, and each must be dealt with upon its own merits, always having regard to the importance of being on the safe side.

Purification of polluted water is accomplished in four ways, namely by:

(1) dilution; (2) time; (3) sedimentation; (4) filtration. When the first two fail or are not available, the third may be employed, but the surest and safest method we know is filtration.

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DISCUSSION.

Mr. E. J. SILCOCK: I am very pleased to propose a vote of thanks for the paper which has been presented to us. It is a most interesting paper and raises points of great importance. The Author gives his views as to the degree of fineness of sand used for filtration purposes and I am disposed to think that he asks for sand of too small a gauge when he speaks of over 60 per cent. of the sand passing through a sieve of 4900 meshes to the square inch. In my opinion such a degree of fineness is neither necessary nor desirable. Sand of a larger gauge will, I believe, answer every purpose; and what to my mind is of higher importance, is uniformity in the size of the particles. The plan I adopt in selecting sand is to have sieves of different sizes and to select by trial the sieve which will remove 10 per cent. of the finest sand from a sample of a known weight. I then remove with a sieve of 900 meshes per square inch all particles of sand which will not pass through that mesh. The balance of the sand left after removing the fine and the coarse is of an approximately uniform size and may be looked upon as the most important part of the bulk. The fraction represented by the weight of the residue divided by the total weight of the original sample gives a measure of the uniformity of size of the sand, and the nearer this fraction is to unity the more suitable, in my view, the sand is for filtration purposes. With reference to the depth of sand to be used in filters, I think 3 feet is as great a depth as is necessary, and I do not agree with taking so much as 12 inches of sand off the filter for cleansing purposes, 6 inches seems to me to be as great a depth as should be removed before the sand-bed is restored to its original thickness. As a matter of management it is more convenient to have sand-washing continually going on, and have the sand removed from one bed and put on to another, so as to keep a uniform depth of sand, rather than have a stock of sand and allow the depth on the different beds to be diminished to anything like the extent of 12 inches. So far as our present information goes, almost the whole of the filtering is performed upon the surface of the sand and that which lies underneath is merely a support for the working surface, and I am therefore disposed to think that a depth of 3 feet 6 inches of sand is far more than is needed. The Author refers to the discoloration of water by peat, and this is a frequent source of trouble with water obtained from

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moorland gathering grounds such as we have in Yorkshire and Lancashire. The discoloration is often very marked and is most difficult to get rid of. It cannot be filtered out and it is only removed by sedimentation and bleaching in the reservoirs. The stain is most noticeable in dry weather when the water in the streams is low and is largely composed of water draining slowly from the beds of peat on the hillsides, which act somewhat as sponges, taking up water rapidly during heavy rain and giving it off slowly after rain has ceased to fall. The flood waters during heavy rains contain much less peat water but are often discoloured by clay, and I have noticed that the clay brought down with the flood water appears to remove some of the peat stain from the water already in the reservoir. I suppose that, in precipitating, the clayey matter must carry down with it the minute particles forming the peat stain. We do not, I think, fully appreciate the value of sedimentation in reservoirs as a means of purification, and in my opinion it is much more necessary to have efficient filtration when water is taken direct from a river than is the case when water is stored in large reservoirs and drawn thence after it has had an opportunity to purify by sedimentation.

Mr. J. PARKER: I am glad to second the vote of thanks, and should like to endorse the remarks which have been made upon the value of the paper. As to the question of water supply, the subject is too intricate a one to speak on in the few minutes which are allotted to speakers who take part in the discussion. It is, however, especially interesting and a suitable subject for discussion in this metropolis of the Midlands, where the corporation are about to inaugurate one of the finest water schemes on the face of the earth. I happen to know something about the Birmingham water-works and admired the scheme from the beginning. My admiration dates from the period when I stood up in Committee Room No. 14 of the House of Commons ten years ago to give evidence *against* the Birmingham Bill. The subject of Mr. Jenkins' paper is an exceedingly interesting one to municipal engineers and especially to those who have the management and control of the pumping, storage, filtration and distribution of water. We have to filter the water of the Wye at Hereford. It comes down to us there in all sorts of conditions: to-day, bright, sparkling, pellucid, when the bacteria would not exceed 200 to the cubic centimetre; to-morrow, after a heavy rainfall, you could multiply the number by twenty. Some of them, the *bacilli coli communis*,

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are known to keep bad company, though relatively harmless in themselves. Sand filtration and large storage capacity does much to arrest bacteria and to make the water more reliable for drinking purposes. Mr. Jenkins has given us diagrams of a mechanical filter, and it may be of interest to Members if I give our experience at Hereford, where the area for either storage or sand filters is limited. We have flood water to deal with occasionally, and consequently one day our water may be perfectly bright in appearance, but on another day mixed with about 10 feet of flood water it looks like a cup of cocoa. The matter in suspension and discoloration is to be arrested. We have experienced some difficulty in persuading the Local Government Board to sanction a loan for one of these mechanical filters, made by Mather and Platt, of Manchester. Mr. Bicknell was the inspector who conducted the inquiry. It was only with some difficulty that we were successful in getting a loan sanctioned for a mechanical filter. We were forced to do this, because we have no room for the extension of the filter beds, so that mechanical filters were in our case indispensable, and at the first test they appear to be a great success.

Mr. T. CAINK: The Author, speaking of public water supplies, says, "The whole history of the water must, if possible, be traced out, and in conjunction with the chemist, the geologist and the bacteriologist must be consulted." Mr. Jenkins has omitted from that list the professional man who should first of all be consulted, or at any rate not take second place with any of the professional men mentioned: I refer to the medical officer of health. It is becoming more and more manifest that the true test of the purity and quality of a public water supply is the health statistics of the town consuming the water. The chemist may tell you the quantity of albuminoid ammonia in the water, the bacteriologist the number of bacteria, but after all the proof of the pudding is in the eating, and the test of the water will be the health statistics of the town consuming it, and particularly the statistics relating to those diseases which, as Mr. Jenkins says, are now proved beyond all contradiction to be water-borne diseases—typhoid fever and cholera. The record of those diseases will be the best test at present known of the quality of a water supply. It has been shown that water subjected to sand filtration gives the best health statistics of any water supply at present experienced. I have been interested in tracing the records of a large number of towns supplied

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with a variety of water, and almost entirely those towns which are supplied with river water (some of them polluted water), when subjected to efficient filtration, show a lower typhoid case rate than many of the towns—in fact most of the towns —supplied with waters which have a reputation for being extremely free from pollution. Take a number of towns supplied with water from the new red sandstone, which has the reputation for excellence of quality both chemical and bacterial. Those towns have a typhoid rate ranging from 150 to 200 cases per 100,000 per annum; while towns supplied with river water, water which receives sewage pollution, when efficiently filtered in an adequate filtering area, even without sedimentation, have typhoid case rates ranging only from 20 to 50 per 100,000. I refer to this in order to show that filtration is capable of producing from a previously polluted water a better and purer supply than is obtained from waters which are chemically purer.

Mr. J. S. PICKERING: I would like to refer to the table which the Author gives of the depth of gravel in the filter. He suggests that 18 inches of gravel should be placed on the bottom of the filter varying in size from $\frac{1}{8}$ of an inch to 2 inches. I am inclined to agree with him, yet we often find that double that depth of material is used. I would instance the present Birmingham filters which we had the privilege of seeing not many weeks ago. Over the whole vast area of these beds there is a depth of 2 feet 6 inches of gravel. To my mind the beds would have been just as efficient with 18 inches of gravel. If that is so it means that a foot of excavation could have been saved, together with a foot of gravel over the whole area. There may have been some reasons for putting this special depth, and I have seen the same depth of gravel in several large works, especially in connection with the London water-works, but I agree with the Author that 18 inches is usually sufficient. Instead of small under-drains, which Mr. Jenkins suggests for draining the filter, I think the better course is to make an artificial floor, because in construction it is found almost impossible to keep the under-drains in proper lines. The men putting the material round them are bound to disturb them, with the consequence that the free flow of water must be interfered with, whereas in the case of an artificial floor composed of perforated tiles your get perfect percolation and draining. I should have liked to have heard an opinion

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on the respective merits of mechanical and sand filters. In America I believe the mechanical filter is almost universally adopted, but I think the reason is that the water they have to deal with is very different to ours. I have read a very exhaustive report which has been made upon the Washington water-works. After experimenting upon a very turbid water for nine months continuously with the mechanical filter and the English sand filter, they came to the conclusion that the mechanical filter gave the best all-round results, both as to getting a brighter water and removing more bacteria. It seems to be the opinion of most American engineers that it is impossible to purify a turbid water through sand. I do not think the mechanical filter will gain popularity in this country, because we have not the same conditions to observe as they have in America.

Mr. J. D. WATSON: The paper contains an exceptionally accurate description of how river water should be filtered. I cannot agree with the criticisms which have been made as to the depth of sand necessary to ensure efficient filtration. My experience of river water and upland surface waters leads me to think that the proportions stated by Mr. Jenkins are well suited for the purpose. It is now well known that purification takes place almost entirely on the surface of the filter, and that objectionable bacteria are arrested in the slimy film which forms on the surface of the sand. There may be some room to doubt whether the amount of sand which is generally used is not more than enough, but so far as the quality and size of the sand particles are concerned, I think there can be no doubt that fine sand on the surface conduces to efficient filtration. With regard to the elimination of peat from river water, I think that nature's way of purifying such water is to expose it to the light of the sun. If this is done for some time, the water loses a considerable amount of its colour, but it comes to be a question of cost, and it may be more economical to effect the desired change by the method recommended in the paper, namely, by passing it through the preparation of alum, than to construct costly reservoirs.

Mr. F. PRICE: I should like to say one word with reference to the question of filtration of water containing clay through sand filters, as raised by a previous speaker. I think you will find it is a question of specific gravity, and the size of the particular atoms you have to deal with. You will find in clay the atom is very small, and the cohesion is greater than with

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sand. If you take sand with a certain amount of clay in it, say 10 or 15 per cent., you will find if you shake a small quantity up in a test-tube with water, that with a little care you can get the whole of the clay at the top of the sand. We have here a Rotten Row, the surface of which is composed of sand with 8 to 10 per cent. of clay in it, and we found that after rain the whole of the clay is on the top, and the surface becomes almost impermeable. If you have any clay in the sand you will find it will almost stop the filtering medium acting effectively.

Mr. JENKINS, in replying to the discussion, said: I felt sure the subject would be one of interest, because it embraces the work of so many of us. As regards Mr. Silcock's remarks on the depth of the sand, I certainly think that in dealing with a highly polluted supply, nothing less than 3 feet of sand ought to be allowed for. Scraping may then be allowed to go on until the minimum of 2 feet is reached. It is not always convenient to be continually replacing small quantities of sand, as the operation takes some time, but where it is practicable there is no objection to doing so. One really ought to be kept to the minimum of 2 feet, because it has been shown that 23 inches of sand are less efficient than 24, and it is important that the fact should be regarded. Eighteen inches of gravel below the sand is quite sufficient, and I would rather reduce this than reduce the sand. As regards the fineness of sand, I hold that the finer you have the sand the quicker you can filter. Of the question of discoloration by peat, I can speak with experience, having had to deal with a water containing a large quantity of peat fibre. Though the storage was over 1000 million gallons for daily supply of 5½ millions, the water was distinctly yellow in colour and was no better after filtration than before. I think Mr. Pickering's suggestion as to under-draining is most important; if drain pipes are used, they should be placed so close together as to almost form the artificial floor he refers to. The important point is to have a perfect distribution, otherwise when filling from below the water will force its way through weak spots in the sand with too great a velocity, and so damage the filter. Mechanical filters have been used in America, chiefly because of the large consumption they have to deal with. The consumption is five or six times as great as our towns, and if they used sand filters they would require very huge ones. There is no doubt the mechanical filter will do

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much more to take out fine silt from the waters of such rivers as the Mississippi and Ohio. I have had some instances of water from which it is impossible to take out the fine silt by sand filtration; no matter how slowly we filtered we could not prevent this fine mud passing through with the effluent.

Communicated Discussion.

Mr. G. E. Hull writes as follows: I consider that the system of sand filtration for a highly polluted river water is inefficient for the thorough bacterial purification. Sand filters in the first instance were designed as mechanical filters only, the bacterial discovery having taken place within the last few years; therefore, it is merely an accident that we possess bacterial filters on the sand system. Mr. Jenkins has shown that the growth of the necessary coating of slime takes seven days or even more; whereby it is clear that, after the filter has been scraped, water of a high bacterial impurity is passed into the supply mains. The use of a sand filter under these circumstances gives a water supply of varying degrees of purity and in my opinion is a source of danger to the public health. The Pasteur-Chamberland filter is a perfect filter for sterilising the most highly polluted water. The porcelain candles are easily cleaned and the working is extremely simple. The only objection is the slow rate of working, which necessitates a large plant for a comparatively small supply. It is interesting to note that a small installation on this principle has been laid down at Darjeeling in India, and is purifying 200,000 gallons per day. If this is possible on this small scale, it would be an excellent filter on works of magnitude.

Communicated reply to Mr. Hull: The first paragraph of Mr. Hull's remarks is fully dealt with in the paper. The Author has no intention of suggesting that water of a high bacterial impurity should be passed into the mains. On the contrary, he has shown that a lower rate of filtration must be used until the beds become ripe and, if necessary, water must be run to waste.

The Pasteur-Chamberland filter is excellent for sterilising water and is probably the only filter in existence that can do so, but its use on a large scale is absolutely impossible under existing conditions, on the score of cost. It has yet to be proved that a sterile water is necessary; the standard of 100 bacteria per c.c. is generally acknowledged to give every safeguard necessary.

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THE POSITION OF LOCAL AUTHORITIES IN REGARD TO BUILDING BYE-LAWS.

By F. C. COOK,
Surveyor to the Urban District Council, Hinckley.

An interesting paper on "Bye-laws as to New Streets and Buildings" was read by Mr. J. S. Pickering at the Congress of the Sanitary Institute held at Birmingham in 1898; but the subject has not been, to the best of the Author's knowledge, previously discussed by the Members of this Association, and it is one which seems particularly appropriate for consideration at a winter Meeting.

Without going into the history of the question, it is well known that bye-laws relating to new streets and buildings made during the past few years are necessarily based upon the "model" series issued by the Local Government Board in 1877, supplemented chiefly by the additional powers granted by the Public Health Act Amendment Act of 1890, and by a few clauses (mostly of considerable value) in addition to, or modification of the whole code. A discussion on this subject, therefore, necessarily resolves itself more or less into a criticism of the model bye-laws, as the basis of the great majority of those now in force in various parts of the country.

There is, of course, no doubt as to the necessity of some such series as a guide to local authorities, and although criticism has been rife as to the wisdom or unwisdom of particular clauses, yet, bearing in mind the difficulty (specially heavy in the first instance) of drafting bye-laws of practical value, unassailable from a legal standpoint, one cannot but admit that the authors of the model code have acquitted themselves well of their task; the objection is not so much to the model series in themselves as to the hard-and-fast rules which seem to govern the officials at the Local Government Board in dealing with suggested de-

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viations therefrom on the part of local authorities; consequently they have come to be looked upon not as intended "for the guidance of sanitary authorities in framing bye-laws" (as stated in the Introductory Note), but rather as the law of the Medes and Persians, which altereth not. Those Members who have had the unhappy task of submitting proposed bye-laws for the consideration of the Local Government Board can fully appreciate the hopelessness of attempting to obtain the official sanction to anything more than practically a mere verbal alteration of the model code.

Whilst criticising the position thus taken up in regard to new bye-laws suggested by local authorities, one must at the same time admit that many of those proposed are anything but typical of what bye-laws should be, and that were the making of bye-laws left entirely to the Councils concerned the results would be, in many cases, worthy of commendation only from the speculative builder's point of view; surely, however, it is possible for the Local Government Board to steer a middle course between these two extremes, and to recognise—as they have certainly failed to do up to the present—the difference between those bye-laws which are and are not essential to the health and safety of those persons who will reside in the buildings, the erection of which they govern.

That this view of the case is to some extent recognised is shown by the reasons given by the authors of the model code for the omission of bye-laws as to the sewerage of new streets: "that the conditions which such bye-laws must satisfy are, to so great an extent, dependent upon the varying circumstances of different localities." Cannot this also be urged in respect of many of the clauses relating to new buildings? Obviously the varying circumstances in the cases of towns of 10,000 and 100,000 population, of districts which although urban in name are rural in character, and of towns, say in the north and south of England, are sufficiently great to justify very material distinctions being made in the bye-laws governing building operations. It is interesting to note, that in the new model series recently issued for rural districts, stress is laid upon the suggestion that the varying character of various parts of a district should be taken into account in the formulation and enforcement of bye-laws.

This brings us to another side of the question—whether it

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is wise on the part of the Legislature to allow bye-laws obviously considered necessary as safeguarding the well-being of the public to be made or not at the will of various local authorities. It would naturally be expected, that where the Local Government Board pay such close attention to minute points, they would at least have introduced legislation making the adoption of bye-laws imperative, or that those made under the Acts of 1875 or 1890, should include all the clauses of the model series in connection therewith; but this is not so. If, for instance, a local authority should desire to make bye-laws regulating the height of rooms, the Local Government Board will assuredly insist upon their model clause being adhered to in its entirety; but, strange to say, they appear to have no objection to the matter being left practically unregulated, even in cases where the Public Health Act Amendment Act is in force. Instances might be multiplied of such cases, especially in connection with this particular statute.

It cannot be denied that the general effect of the adoption of bye-laws based on the model code has been to considerably raise the standard of building throughout the country; it may also be asserted that if conscientiously carried out they could not fail to produce an improved condition of things, particularly as regards the sanitary condition of new dwelling-houses; on the other hand, it is questionable whether, in the case of the smaller towns, they do not unnecessarily retard building operations to their detriment, and that in larger towns the increased cost of building added to the high price of land, renders almost prohibitive the ideal of one family occupying one house, and results in the consequent overcrowding, which is such a blot upon the sanitary condition of some of our large cities.

Through the courtesy of his fellow Members the Author has recently had the opportunity of comparing the bye-laws of some 75 towns in the Midland district; briefly, the results are as given below:

Towns governed by bye-laws made previous to 1877 ..	13
Ditto, made subsequent to 1877, but prior to 1890	19
Ditto, made (more or less) under the Public Health Act Amendment Act of 1890	15
Ditto, made subsequent to 1890, but only under the Public Health Act of 1875..	7
Ditto, supplemented by Local Acts	4
Bye-laws under revision	16

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One town relies upon bye-laws made by its council in 1881, but which have apparently never been officially sanctioned; in this case it is not surprising that the minimum width of new streets is given as 30 feet.

The reason for this truly chaotic state of things is not far to seek; it lies, surely, in the "all or none" attitude adopted by the Local Government Board in considering bye-laws suggested by local authorities; although there is, in the great majority of cases, no pressure brought to bear upon them to bring their bye-laws up to date, yet, should they be progressive enough to do so, nothing but practically a strict compliance with the clauses in the model code will receive the official sanction; the local authority are thus left in the unfortunate position of having to enforce bye-laws, the provisions of which they think unnecessary, allow them to become practically a dead letter, or rub along as best they can with those which are admittedly out of date; amongst those towns relying upon bye-laws made prior to 1877 are some of the largest in the Midland district. It may be urged that this is a state of things not creditable to the various councils concerned, but at any rate it is a reflection upon the methods pursued by the Local Government Board; indeed, one cannot but think that if the difficulty of enforcing certain bye-laws, or the reasons for not enforcing them at all, could only be brought home to them, a different state of things might be initiated.

Advantage has been taken of many of the alternative clauses issued since the first publication of the model series; perhaps the most important are those in substitution of the original clauses in regard to the continuance of party walls above the roofs of houses, the covering of all building sites with concrete, and the provision of open space to stables and other buildings appurtenant to and erected at the rear of dwelling houses. The additional clauses—chiefly as to excavated and low-lying sites, the provision of eaves-gutters and down-pipes, and the granting of certificates of habitation—are also included in some of the bye-laws of the towns referred to. Modifications, however, obtained in particular cases, are few and far between; in one or two of the most recent sets of bye-laws no reference is made to the number of stories in the case of walls not exceeding 25 feet in height and 30 feet in length; the height of a story necessitating a 13½-inch wall is increased from 10 feet to 11

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feet; piers are provided for in lieu of return walls; and in rubble walls no increase in thickness is necessary, if one-fifth of the total thickness is built of brickwork distributed in piers and horizontal courses. There is also in one town a somewhat peculiar modification of the model clause, where a coal-house is allowed to be built upon the open space provided at the rear of a building. With the exception of these, and some comparatively trivial alterations, the various clauses of the model code must be adhered to in their entirety.

There appears to be one way by which a different state of things can be attained, and that is by the amplification or modification of bye-laws by means of a private Act of Parliament; but, unless an Omnibus Bill is in contemplation, this is obviously beyond the power of at any rate the smaller districts, and it seems a somewhat questionable way of gaining the desired end. If the bye-laws issued by the Local Government Board are to be regarded as a "model" series, surely it should not be possible to get behind them, so to speak, by means of a private Act; or again, if modifications and amplifications so obtained are fit and proper powers for a local authority to enjoy, they should be within the reach of every town without the trouble and expense of promoting a private Bill. It is, of course, a fact that many of the powers so granted could not be made the subject of bye-laws under any existing Act of Parliament, but that only renders necessary the promotion of the requisite legislation by the department concerned.

In the case of one town with a population of upwards of 30,000 the council are empowered by a special Act (passed in 1883) to particularise the thickness of walls, provided no party walls are less than 4½ inches; there is no mention of an intercepting trap, and rooms in the roof need only be 7 feet in height over one-half the floor area; surely something must be radically wrong if a local authority are enabled to obtain from Parliament powers to deviate to such an extent from conditions which the Local Government Board consider essential to health and safety!

On the other hand, many clauses contained in private Improvement Acts are decidedly beneficial; such, for instance, as power to attach conditions of approval to plans; the rendering void of such approval if the building be not commenced within a specified time, and prohibiting the commencement of building operations until the plans are approved by the local authority;

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the enforced provision of movable receptacles for ashes in lieu of ashpits; the construction of factory chimneys; the laying-out of courts; the legalisation of regulations made from time to time by the local authority; the application of bye-laws as to the drainage of buildings in cases of re-drainage; and a settled definition as to what a "new building" really is. One bye-law made under a local Act even provides in connection with water-closets for the fixing of pedestal closets with lift-up seats—in the Author's opinion a very great sanitary improvement in many respects. There are other provisions doubtless excellent in themselves, but perhaps more of local than general interest.

Some towns attempt the same results by means of "instructions" or "regulations"; whilst no doubt effective, it must be admitted that this is a somewhat dangerous method to employ. There is, generally speaking, no legal authority for these regulations, and consequently the first seriously contested case has only to be taken into court for the futility of the whole system to be exposed—when the last state would be considerably worse than the first.

In the limits of a paper such as this it is hardly possible to attempt any very detailed criticism, but there are some matters which come to mind as specially calling for revision. There are, for instance, the requirements of the model series as to the provision of air-space at the rear of dwelling-houses; these have been modified to some extent by the insertion of provisoes as to corner and tapering sites, but in only one case can the Author call to mind a series of bye-laws in which these are included. The great sacrifice of property (particularly in the centre of our older towns), which the enforcement of these bye-laws would entail has frequently been pointed out to the Local Government Board, though their existence would probably not deter a local authority from adopting a give-and-take policy (especially in the case of re-building) with the object of effecting a public and oft-times sanitary improvement. It is interesting to note that in the new model bye-laws for rural districts it is admitted that there "may be exceptional circumstances which would render it unnecessary to require the provision of the amount of open space referred to, e.g. in the case of dwelling-houses abutting upon a park or other open space dedicated to the public," and it is intimated that this is a modification which may be regarded as applicable to urban districts.

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The concessions which have recently been made in regard to the structure of walls, have been already referred to; they are of such a nature that it would be well if the model clauses were amended accordingly, for it cannot be urged that this is a question of locality. These bye-laws, even as modified, still press heavily in many respects, though it is difficult to see how they can be made sufficiently elastic to meet all cases.

A bye-law, small in itself, but difficult to carry out in practice, is that as to the ventilation of habitable rooms without fireplaces. A sectional area of one hundred square inches is larger than that of the chimney flue of an ordinary bedroom, and were such an opening actually provided, there is not much doubt as to how long it would be allowed to remain unobstructed.

Many of the bye-laws framed for the prevention of fire appear unnecessarily stringent, and in many respects to needlessly detract from the strength of a building; their effect on architecture is apparent to the most casual observer in the dismal sameness of the appearance of those localities where a number of houses have been erected in conformity with them. This is particularly the case in some of the London districts.

Having regard to the wide divergence of views on the subject, it is perhaps useless to hope for any material alteration of the clauses as to the provision of intercepting traps. It has been proved beyond question that in ordinary cases a 2-gallon flush is not sufficient to ensure a clearance; that being so it is surely questionable whether their retention is not detrimental, rather than a safe-guard to the sanitary condition of a dwelling-house; it may be urged that the difficulty would be overcome by the enforced provision of 3-gallon flushing cisterns, but this is a remedy which would prove a serious matter in some districts from the point of view of water consumption. If an intercepting trap is insisted upon, the provision of an inspection chamber in conjunction therewith is most desirable, but this is not required in many towns at the present time. Connected with this question is that of the ventilation of house drains; the Local Government Board have recently issued an amended clause insisting upon the fixing of an upcast shaft only, in cases where the water-closet is built outside a dwelling-house and the drain does not exceed 30 feet in length. In the Author's opinion it is desirable to still further extend this modification, for the presence of a "fresh-air inlet" (which frequently acts as a foul-air outlet) in

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what is usually a most objectionable position, is anything but an advantage from a sanitary point of view. The modification above noted, is printed as a proviso to the original clauses in the new bye-laws for rural districts, and the minimum diameter of a ventilating shaft in the case of a 4-inch drain is therein given as $3\frac{1}{2}$ inches.

On the other hand, there are bye-laws which hardly seem to go far enough: those, for instance, allowing the construction of an earth-closet within a dwelling house and the erection of a privy within a distance of 6 feet thereof—both of which matters are dealt with in the new rural series. There is one bye-law, in particular, which cannot be regarded as unduly stringent: that in regard to new streets specifying 36 feet as a minimum width. Taken in conjunction with the comparatively large area insisted upon at the rear of dwelling houses, an open space of 36 feet between possibly the front main walls of three-story buildings in the heart of a large town scarcely seems sufficient. The Author does not know of any town where such is the case, but a bye-law specifying a minimum width of 40 feet with a reduction to 36 feet where forecourts are provided would be beneficial without pressing heavily upon landowners.

There is another point which cannot be overlooked in discussing this matter—the question of inspection. Even the most reasonable sets of bye-laws are necessarily somewhat complicated, and builders, however well-intentioned, are apt to go astray unless their work is under constant supervision. Where the finances of a town allow of the maintenance of a staff of building inspectors the difficulty is removed, but in the case of the smaller and poorer districts it remains a very great one; to ensure strict compliance with building regulations in towns in which building operations are only moderately extensive, demands such supervision as a surveyor with a staff—ample, it may be, for other purposes—is quite unable to give. Whether the question is of such importance as to warrant some such financial arrangement being made as in the case of sanitary inspectors, is one which may yet come to the front; it may certainly be argued that a careful superintendence of the construction of dwelling-houses, especially so far as the health of their future occupants is likely to be concerned, would render the work of sanitary inspectors proportionately lighter in years to come.

The Author's endeavour has been rather to provoke discus-

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sion than to suggest remedies, but there appear to be three main lines upon which any suggested measure of reform should run:

(*a*) A levelling-up, so to speak, by the compulsory adoption of modern bye-laws in districts which are at present behind the times in this respect.

(*b*) The formulation of a code of model bye-laws confined to those points which experience has shown to be essential.

(*c*) The empowering of local authorities to make supplementary bye-laws and regulations, specifying what may be regarded as matters of detail, and containing provisions specially suitable for the needs of different localities.

There is evidence on all hands of dissatisfaction at the existing system, and probably a consensus of opinion as to the desirability of a change; but it is a matter in which the views of various local authorities, casually expressed from time to time, can carry but little weight. Should Members be of opinion that the subject is of sufficient importance to warrant further serious consideration, with a view to the whole matter being placed upon a more satisfactory footing than at present, one can hope, without being unduly optimistic, that representations from the Council of this Association as embodying the views of those who by everyday experience are brought into close contact with every aspect of the question, would have some effect with the Local Government Board.

DISCUSSION.

Mr. J. PRICE: I have pleasure in proposing a vote of thanks for this paper. It is an excellent one, for it shows that the writer has well thought out many of the questions which we have to deal with when we go to the Local Government Board in the matter of bye-laws. There is a great want of elasticity on the part of the Local Government Board in dealing with bye-laws. One is surprised to hear an answer recently given by the President of the Local Government Board to a question asked in Parliament. It related to the housing question, and was put by Mr. Duke of Plymouth, who wanted to know why the Board required something entirely different in houses built by the local authority to what was required from the ordinary speculative builder. Mr. Long said, in reply, that

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they never interfere in such matters. We know that is the official answer, but it is not the truth. In drafting our new bye-laws we had a separate definition of a dwelling house and of a domestic building. We put before the Local Government Board new bye-laws as to the space to be allowed at the rear of a dwelling house. We wanted to put in the bye-laws "dwelling house" instead of "domestic building," but the Local Government Board would not assent to it. And now, after consulting the Builders' Association, the builders raised the very same point: they said that it is unreasonable when dealing with offices in the centre of the city to ask for the same air space as for a dwelling house in the suburbs. That is, however, the Local Government Board's requirement. Now we are trying to get over that difficulty, and with a view of doing that, we have had to frame a bye-law as to "dwelling houses," and another as to "domestic buildings," quite separate one from the other. Then we have a question such as the plan * shows. That is a plan submitted with a view to solving the housing problem. The houses each contain a living room, bedroom, w.c. and ashpit. But the question arises whether, if we built houses on that plan, the passage between such tenements is a front street. You will observe that bye-law 9 says, "Every person who shall erect a building within one curtilage containing a number of tenements under one roof and approached by a common entrance or entrances, shall cause such building to have a frontage to a street of not less than 36 feet in width." Supposing there was no roof this is a passage or court. What is the difference between that and the street in front? Where is the bye-law that touches it? In London they build houses on this plan under the Building Act, but, technically, as it stands, such a building is an infringement of the bye-law. But is there anything against it, providing we have the passages of the proper size, proper lighting, and so on? There is nothing against it. It is better than many of the buildings put up to day. Of course bye-laws are only made for those who do not wish to carry out the law of the land. For the good builder bye-laws have no terror. Then another question is that of tall chimneys. Plans have been submitted to me for a patent "Alphons Custodis" chimney. Scientifically it is a good chimney, and it saved something like

* Plan appended.

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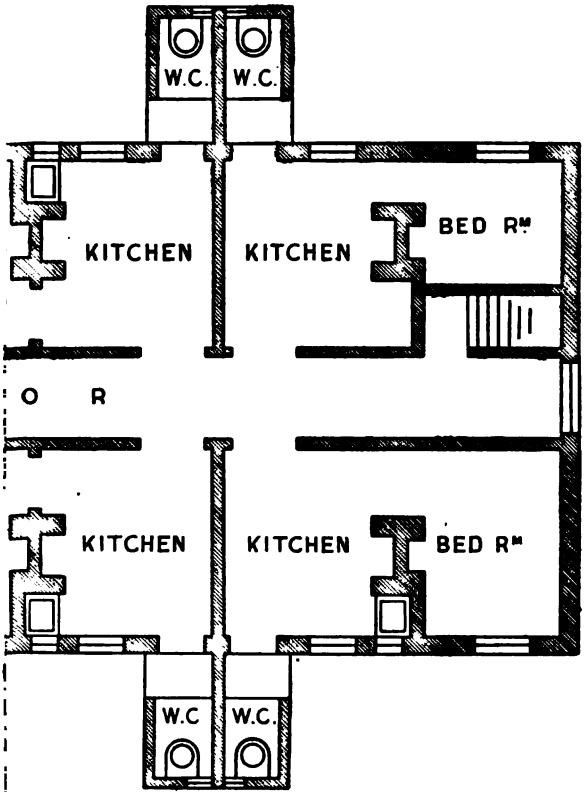

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33 per cent. of the cost of an ordinary brick chimney. But is there a bye-law which allows the erection of such a chimney as that? I know several chimneys have been erected on that plan. But they have put a plan before the Local Government Board in brickwork, and then erected the other. But is that a right course to take? I have got a provision for dealing with such chimneys in the new bye-laws which reads, "He shall cause the walls of such chimney stack, shaft or flue to be built of materials of the best description and quality of their respective kinds and to be of adequate strength to secure perfect stability." That is to say, they have to leave it to the builders and local officials to settle the question of stability. That is a proper provision to make, so that when somebody sends in a plan for a chimney it will be considered on its own merits. That is a bye-law which has not yet passed the Council, but has been provisionally approved by the Department. Those are the kind of things we have to deal with when we deal with the Local Government Board. One, however, feels that during the last few months there have been influences at work at the Local Government Board which did not formerly exist. I have been met on this question of bye-laws in a very different spirit to what I have in past years. In concluding his paper, Mr. Cook hopes that representations from the Council to the Association as embodying the views of those who, by everyday experience, are brought into close contact with every aspect of the question, will have some effect with the Local Government Board. Now, at a meeting of the Council this very question of rural bye-laws was raised, and the Secretary was requested to write to the Local Government Board and ask them to let the Council see their proposed model bye-laws for rural districts before they were issued. The reply from the Local Government Board was such as to lead us to suppose that this would be done, but I have heard from the Secretary that the Local Government Board have sent a copy of the model bye-laws for rural districts "after issue," with a note that they are intended only as a specimen. If they had sent them in draft the Council could probably have suggested some practical amendments which would have increased their value. The position taken by the Local Government Board is not one which should be taken by a great public department in a matter of this kind.

Mr. A. D. GREATOREX: My corporation are at present

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considering the question of bye-laws. Unfortunately my corporation is one of those mentioned on page 144. The bye-laws of the West Bromwich Corporation are about the oldest in the country. They were made many years ago, and they consist of only ten or twelve bye-laws. They generally sum up by saying that the strength and size of materials, etc. shall be such as shall be approved by the authority. Notwithstanding this we have not had any great difficulty in dealing with the local architects and builders. We have from time to time made alterations as to the thickness of walls, etc., and we have generally managed to get them carried out. Two years ago we were instructed to prepare new bye-laws, and after a good deal of work they were drafted and submitted to the Local Government Board. I might say they were first submitted to the local architects: who appointed a committee to consider them. The architects' committee met the committee who had the bye-laws under consideration and made suggestions to them, which in certain cases were agreed to. Then the completed bye-laws were sent to the Local Government Board and they returned them with all the suggested alterations from the model bye-laws struck out. Therefore all the work we had done and the number of committee meetings we had held in considering the bye-laws, was a waste of time. However, we have not given up hope, and I am now preparing an answer respecting the bye-laws struck out by the Local Government Board. We, like Birmingham, are hoping to have some of the amendments to the altered form agreed to. In fact, I may say some of the amendments have lately been agreed to, but not so many as we desire. I think a very good way of dealing with building bye-laws is one adopted by Mr. Price two years ago. Mr. Price called together the surveyors in this district; we met from time to time in his office and discussed the various bye-laws of the Local Government Board. I think that was a very good thing; particularly for those surveyors who had new bye-laws under consideration. We got the experience of the different borough surveyors, and in many cases it was of extreme use to us in preparing new bye-laws. If not too big a thing to undertake I think it would be a good thing if the surveyors in each district into which the Association is divided were to hold meetings of this kind and discuss some of the more important bye-laws; and after discussing them and coming to a unanimous decision,

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if the draft bye-laws upon which they agreed could be sent to the Council and amalgamated into a whole, and then submitted to the Local Government Board as a model set. In that way we should arrive at something workable. It may be undertaking a large order, but at the same time I am convinced it would be a good way to arrive at a set of bye-laws which would be suitable for all towns. There is one thing to bear in mind. We ought to make bye-laws which can be easily and readily understood both by the builders and by owners of property. In many towns the majority of house property is put up by the owners themselves without employing architects to look after their construction; and very often questions are asked respecting the bye-laws by persons who are not architects or builders, and they ought to be drafted so that they can understand them. The chief aim of the bye-laws is to make property healthy and suitable for people to live in.

Mr. J. LOBLEY: One peculiarity of the paper is the moderate tone in which Mr. Cook speaks of the Local Government Board. I am sure the moderation of his remarks is most admirable. Some of the decisions of the Local Government Board are so fearfully and wonderfully conceived that strong language seems permissible. Perhaps, though, Mr. Cook, in writing this paper thought it might be brought before the notice of the Local Government Board, and that it might be a good thing to be gentle in tone. Nothing but very strong and united action has any effect. After many years of such representation the Local Government Board have certainly made some concessions in their model bye-laws; particularly one, that party walls need not in all cases be carried through the roof. The former requirement originated in the idea of stopping any extension of fire from one house to another. No one in my town has ever heard of a fire extending to another in this way, and to put all the party walls through the roofs—causing thereby very serious disadvantages—was a very unwise requirement. When the Public Health Act of 1875 was before Parliament, it naturally attracted attention amongst town surveyors. I remember that I took great interest in it myself, and the report I made to my Council was adopted by them and forwarded to the Local Government Board. That report was printed in the *British Architect* in the spring of 1875. One point only I will allude to. You all know the clause where a building is pulled down

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your authority can define the building line of the street. But there is no definite power to deal with a piece of vacant land. Now that struck me as a strange thing. You have actually more power, explicitly stated, where a building exists than for a piece of vacant ground. Attention was called to this clause and the Local Government Board were asked to amend it so as to enable the local authority to deal with the vacant land by defining the building line. They replied that there was no need to alter the wording of the clause because the authorities had power under their bye-laws. That must be a bye-law I have never yet found. I doubt whether any authority has power to object to any plan unless it specifically infringes a bye-law. I have carried out many street improvements, and have got along pretty well by agreement, but we want the absolute power to deal with vacant land. It is a very different thing if you have absolute power than if you have to go to the owner, and to say, "We want to come to some agreement with you as to the building line." I remember a case which occurred thirty-three years ago at Smithdown-road, Liverpool. The corporation tried to get the owners to set the building back, but they could not agree as to the price to be paid. The corporation at last said to the owners, "If you build up to your line and do not set back, there will be no footpath in front of the property, as we cannot sanction the carriageway being narrowed." It was built in that way, but I dare say it has been altered since.

Mr. J. PRICE: Not to my knowledge. It was there the last time I was in Liverpool.

Mr. LOBLEY: The law as it stands is fairly good for dealing with existing streets for widening and improving the building line; but when you come to new streets the law is not so good. When the owner of a field lays out that land in new streets the power of the local authority to alter those lines is limited. It is not so full as it ought to be. I certainly have not been able to find sufficient power to back me up in requiring alteration in the plans sent in, sometimes a very radical alteration of the lines and widths of the road or street. Each owner—of course this applies more particularly to places where every field belongs to a different owner—wants to lay out his own land to the greatest advantage to himself. Of course, in Birmingham, where they have one owner, say for Edgbaston, they can make lines suitable for the whole neighbourhood and lay out the land for the good

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of the district. But in other towns where each field or so belongs to a different owner, the difficulty is very great. We want bye-laws to enable the authority to say positively where the new street line shall be. If it was in a bare form like that it would press hardly upon different owners because one would give up more land than another. Consequently, it wants very carefully arranging with a clause as to arbitration. The authority should not only have the power to require an altered line, but they should have the power of defining the line of a new street for not merely one field or one owner but for several owners, and to pay compensation to the persons interested if entitled as settled by an arbitrator in the usual manner under the Lands Clauses Act. One remark in the paper strikes me as a very good one. Speaking of the 36-foot minimum, Mr. Cook says that might be safely increased to 40 feet where there are forecourts. Now the 36-foot minimum generally becomes a maximum as well. Rarely do we hear of land-owners giving more than 36 feet. The Local Government Board have been pressing us to adopt the model bye-laws, but in many respects our bye-laws are better than the model bye-laws. We have a bye-law which enable us to increase the width of a street according to its length, but we have no power to pay compensation. This struck me very forcibly when I visited America. There, wide and straight streets and streets at right angles are the prevailing model. They plan out the extension of a city for ten, twenty or thirty years ahead and the street must be where it is laid out on paper when the time comes for making it into a street. And that is what should take place here. We should have more difficulties because there are more owners. But there should be some means of defining the line of new roads and streets. There should not be a general width of 36 feet for streets. We want streets of 60 feet in places, and to secure this, power should be given to the local authority to pay compensation. Just imagine what is going on all round London. Take the districts outside the County Council boundary. Is there a single trunk road leading out of London which did not exist a hundred years ago? The same thing applies to many other towns. The towns are growing enormously, and yet no provision is made for new roads leading out into the country in sufficient number, on good lines, widths and levels.

Mr. H. PRICE: I must thank you for this opportunity of

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speaking on a subject in which I am very much interested. I have listened to the paper, and it seems to open up tremendous ground for discussion. The architects, through the Royal Institute of British Architects, have been interesting themselves in this question for some time, particularly with regard to the bye-laws for rural districts, and there is no doubt they have got certain concessions in the last model set issued by the Local Government Board for rural districts. I do not want to go over the ground again, but referring for a moment to what Mr. Lobley has said, I might draw attention to some recent Acts of Parliament, especially those of West Bromwich, Southport and Leicester, where additional powers are given for defining the building line. There are certain points in this paper which might be enlarged upon somewhat, and especially in regard to details. The Local Government Board latterly have been making much greater concessions than they ever did in their history. I notice walls are mentioned, and that certain requirements as to a cottage comprising more than two stories are omitted. The Local Government Board have gone further than that. In bye-law 19, sub-section (*b*) they have altered the thickness of the walls, allowing the bye-law to read, "it shall be thirteen-and-a-half inches thick for the height of one story and nine inches thick for the rest of its height," instead of "it shall be thirteen-and-a-half inches thick below the topmost story, and nine inches thick for the rest of its height." The policy they have adopted of having all or none has worked very badly indeed. Now in Birmingham, we find, that in 1876 certain bye-laws were made. Those bye-laws provided for an open space at the rear of dwellings which did not exceed 25*l.* net rateable value. When in later years we altered those bye-laws they wanted us to take up the model set in their model series. What is the result? That Birmingham as to open spaces is acting under the bye-laws of 1876. Consequently, when we get a good sized villa we have no power to order any space at the rear. And you can imagine the result. Now timber is a matter which is not mentioned. The Local Government Board adopted the standards of timber worked out by Mr. Goldshaw in his Liverpool Building Act. But these standards are not applicable to Birmingham or the Midlands. And the result is that, any district which adopts the model bye-laws of the Local Government Board as to timber finds in the administration of

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those bye-laws one of their greatest difficulties, because it is almost impossible to educate the speculative builder in multiplying the depth by itself and the product by the width. In Birmingham Mr. Price has got over that difficulty by having prepared a table giving the results of the square depth multiplied by the width for the different sizes and lengths of timber in use in the district, with the centres and distances at which they may be used. He has issued that to the surveyors in the district and it will be found exceedingly useful. That table has been placed before certain officials of the Local Government Board, and they say they would be pleased for it to be issued as an appendix to the bye-laws. Why do they not see the error of their way in this particular and why do they not mend it? What is the result of this dead letter system in our bye-laws? When we have to prosecute and go before a bench of magistrates, they say, "You do not apply such and such a bye-law. Why do you want to apply this one?" I believe whatever bye-laws are made ought to be thorough and should be gone into by a body of competent men, who know what the actual process of working out is, and not a body of men who are in their office all day long, and have no experience of the working out of those bye-laws. If we had bye-laws on those lines there would be greater uniformity in working, and we should get better and more beneficial results.

Mr. G. W. LACEY: With the other speakers I feel disposed to congratulate Mr. Cook on the very thoughtful paper he has prepared on this subject. It seems to me he has anticipated most of the objections which can be raised, and dealt with the anomalies that occur, and therefore the paper does not leave very much room for more than to air one's grievances against the Local Government Board. There are, however, one or two points which occur to me. The first is with respect to plans for buildings. There is very great difficulty in getting plans for alterations to existing buildings, and the Author in his paper suggests the need for a definition of a "new building." If it were made compulsory for plans to be submitted for all alterations and additions, as well as for new buildings, it would save a great deal of trouble and would do away with the need of a definition. In the same way as water authorities have power to require notice of all alterations or additions to their services, municipal authorities should have the power to insist

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upon plans for all alterations and additions to buildings. Then as to new streets. Mr. Cook mentions the bye-law as to the width of street, but there is no specification of the construction. I am of course aware that this can be dealt with later under the Public Health Act and the Private Street Works Act, but I think it would be advisable, that included in the bye-laws there should be some statement as to the construction of a new street. The requirements would, of necessity, vary in different districts, and the local authorities should have the power to lay these down.

The PRESIDENT: I think I must say this is a very successful first winter meeting. We have certainly had a very good discussion, but I think it would be better at future meetings to have only one paper, because I am certain there are many Members present who would have liked to take part in the discussion. I would suggest that at a future meeting we might have another paper on bye-laws. I think it would be thoroughly worth our while to do so, considering our difficulties with the Local Government Board. We have had great difficulties at Leicester, and the conclusion we came to was to stick to our old bye-laws which gave us greater powers than the new ones. The only thing we do is in our omnibus bills to get our powers extended.

Mr. J. S. PICKERING moved "That the Council of the Association be requested to take into consideration the existing unsatisfactory condition with respect to the making and administration of bye-laws relating to new streets and buildings, with a view to representations being made to the Local Government Board thereon."

Mr. J. PRICE seconded the proposition, which was carried.

Previous to the discussion of the papers, the Members were entertained to tea by the Lord Mayor (Alderman J. H. Lloyd), to whom a hearty vote of thanks was accorded.

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DISTRICT MEETING AT NEWBURY.

May 31, 1902.

Held at the Town Hall, Newbury.

E. GEORGE MAWBEY, M. INST. C.E., PRESIDENT, *in the Chair.*

THE Mayor of Newbury (Mr. Councillor John Rankin) offered the Members a very hearty welcome to the town.

He trusted that although Newbury was but a small place, yet the Members of the Association would find their visit both interesting and instructive. He was sure that they would all be deeply interested in the papers to be read at the meeting.

The President, in returning thanks for the cordial welcome that had been offered to the Association, took the opportunity of pointing out to the Mayor and Corporation that the older Members of the Association were always delighted to inspect the works of, he might say, the younger Members, which were equal in merit to those carried out by wealthier and larger Corporations.

Mr. R. J. THOMAS, Aylesbury, Hon. District Secretary, read the minutes of the last District Meeting held at Southend, which were confirmed.

The following papers were read and discussed :—

NEWBURY MUNICIPAL WORK.

BY S. J. L. VINCENT, A. M.INST.C.E., BOROUGH SURVEYOR.

STATISTICS.

Population (about)	11,600
Area	1,813 acres
Rateable value	£40,500
Indebtedness—Urban Sanitary Authority	£37,900
Borough Fund	£8,000
Number of houses erected since 1892	330
Death rate—All causes	15 per 1000
Zymotic diseases	0·5 „

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Newbury has received four Charters, viz. one from Elizabeth, 1595; one from Charles I., 1627; one from Charles II., 1664; and one from James II., 1685.

A record of the names of the Mayors of the Borough from the year 1595, is painted on the walls of the Council Chamber.

Roads.

There are 7¼ miles of main roads in the borough (the Berkshire County Council contributing 1250*l.* per annum) and about 11 miles of streets and roads other than main roads.

For the main roads, Clee Hill granite, broken to 1½-inch gauge, is used, the roller being a 10-ton Aveling & Porter.

For the other streets and roads, local gravel, hand-picked flints and Sarson stone are used.

In June 1900, the roadway on two sides of the Municipal buildings was paved with karri blocks on a bed of Portland cement concrete 9 inches thick gauged 5 gravel to 1 cement; area 474 yards; cost 309*l.*

During the last three years about 12,000 yards super of concrete footways have been laid at an average cost of 3*s.* 4*d.* per yard superficial.

The footways are laid *in situ*, the thickness being 2¾ inches, the bottom 1¾ inches being composed of four parts local shingle gravel (¾-inch gauge) to one part Portland cement; and the top 1 inch two parts fine beach shingle (⅜-inch gauge) to one part Portland cement. The paths are laid in bays of an average area of 30 superficial feet.

Private Street Works.

This Corporation has not adopted the Private Street Works Act, so that all private street works are carried out under Section 150 of the Public Health Act, 1875. During the last three years, six streets have been made up under notice from the Council. The specification is (shortly) as follows:—

Excavate old surface 9 inches deep and sift out all soil through ¾-inch sieves. Roll in 9 inches rough stone in 3-inch layers, finish top surface with good local gravel rolled by a steam roller at least 8 tons in weight. Pathways each side to be one-sixth of the width of the roadway, and to be 2¾-inch concrete with 6-inch by 10-inch concrete kerb.

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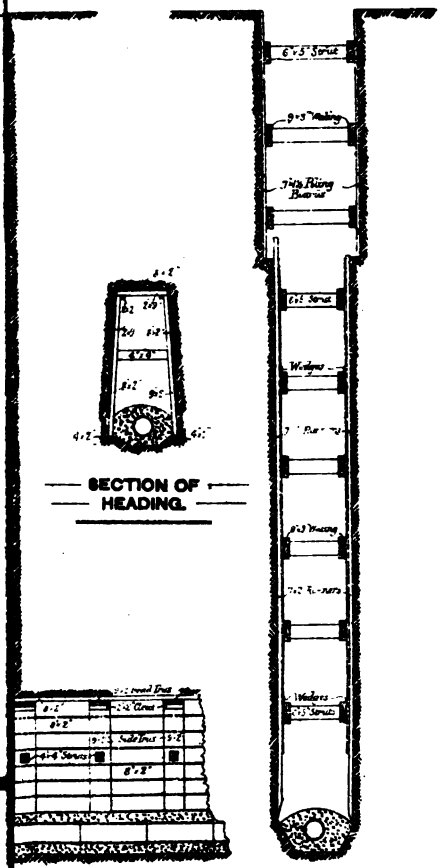

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No channel is insisted on, although the Author considers it necessary in all roads. The average cost per lineal yard is 24*s.* or 4*s.* per foot of frontage.

SEWERAGE.

The main sewerage system of the borough was designed by the late John Anstie and carried out by him during 1894, 1895, and 1896. It is entirely on the "separate" principle. There are 13 miles 2 furlongs of sewers. The main sewer at the receiving well is 16 inches in diameter, the other sewers ranging from 12 to 8 inches. The whole of the sewage flows by gravitation to the receiving well at the pumping station, whence it is pumped by three 7-inch centrifugal pumps to the outfall works, 2¼ miles away, the power being supplied by three gas-engines, two 12 horse-power, and one 7 horse-power. The charge for gas for pumping is 2*s.* 4*d.* per 1000; this equals a cost of 1*d.* per 2700 gallons. A house for the engineer was added last year at a cost of 290*l.* The whole of the work is now done by one man. There are twenty-four automatic flushing tanks at work fed from the mains of the water company. The ventilation of the sewers is effected by surface gratings (open man-hole covers) and shafts, of which we have now sixty-four of 4-inch diameter and fifteen of 6-inch diameter.

At the outfall works, the installation consisted of six precipitation tanks, and a complete set of sludge-pressing plant, the land being about 11 acres in extent, of which one-half is underdrained.

The total cost of the system was as follows:—

	£	£
Land at outfall works		2,299
Land at pumping station (whole of farm purchased)		3,350
Sewers, receiving well, delivery mains, etc.		19,100
Buildings—pumping station	£974	
outfall works	902	
		1,876
Precipitation tanks and laying out land, etc.		1,275
Machinery		1,665
Sundries		550
		£30,115

Since the Author's appointment in May 1897, considerable extensions have been made to the sewers, and the system of treatment has been altered. The length of sewers added is

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2950 yards of 8-inch and 9-inch. At present an 8-inch sewer 2730 yards long is being laid to take the sewage of a portion of the borough known as Wash Common, a district which is a plateau 160 feet above the average level of the town. The greatest depth of this sewer is 31 feet 6 inches, over 600 yards being more than 25 feet deep. The work is done in sections of 12 feet open trench, and 12 feet "heading," the soil below 15 feet in depth being slimy running sand necessitating close timbering. So far 1030 yards have been completed. The whole sewer is surrounded with concrete. The Author has constructed all the man-holes on the whole of the extensions carried out by him of concrete and tiles (thus providing a completely glazed surface easily cleaned), at a cost less than that of rendered brickwork.

The whole of the man-holes on the system (240) are thoroughly cleaned once a quarter, the sides, benching and invert being scrubbed with a stiff short-handled broom and afterwards flushed out. The cost of this work is 3¼*d.* per man-hole.

Up to December 1899 the whole of the sewage was treated chemically and passed through precipitation tanks. The Author having visited works where bacteria beds were in successful operation, suggested to the Main Drainage Committee in October 1899 the advisability of converting one of the precipitation tanks (60 ft. by 24 ft. by 4 ft.) into an experimental bacteria bed. This was done by filling it up with furnace clinkers—sewage was passed into it in December 1899. The results were so satisfactory that two other tanks were converted in the following March, a change being made, however, in the material used, the manager of the works having suggested a trial of clean sifted shingle dug from a portion of the land at the works. These two beds proved even more satisfactory than the clinker bed, so that after six months' working the Author induced the Main Drainage Committee to construct a sufficient area of bacteria beds to treat the whole of the sewage bacteriologically. Accordingly, five concrete tanks of a cubical capacity of 260 yards each (60 ft. by 24 ft. by 5 ft.) were constructed and filled with gravel. They were first charged on June 24, 1901, and have worked continuously ever since. They are worked on a six-hours cycle (i.e. filled four times in twenty-four hours). The use of chemicals and the work of sludge-pressing ceased on the same day, the saving in these two items being over 300*l.* per annum. The capacity of these gravel beds

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when first charged was about one-half the total cubical contents of the empty tanks; after a few days this had shrunk to one-third, and at the end of three months to one-fifth, at which figure it has remained since. The effluent is passed over the land, and has proved satisfactory to the Thames Conservancy analyst. It has proved that these beds do not deal with the *whole* of the sewage, but with only 220,000 gallons out of a total flow of 340,000 gallons per twenty-four hours; consequently one of the precipitation tanks is still used for the surplus flow, the sludge which accumulates being passed into a prepared bay on the lowest portion of the land. The cost of these beds (410*l.*) was paid out of current account. The Author proposes next winter to construct additional beds to deal with the surplus.

As regards house-connections, a set of regulations was framed by the Main Drainage Committee and approved by the Local Government Board. These include the compulsory provision of an intercepting chamber to each connection with the sewers. A plan and section of each house-connection is prepared and kept by the authority. Houses may be grouped for drainage purposes, separate connection for each house not being insisted upon.

A public convenience was constructed under the "Shambles" in Mansion House Street, in 1900. It is built of concrete and white glazed tiles, lighted by means of pavement lights, and contains five urinal stalls automatically flushed, and two water-closets, with penny-in-the-slot apparatus. The cost (130*l.*) was paid out of current account. So far the receipts from the closets have averaged 6*s.* per week.

Corporation Depôt.

In December 1897 the Author obtained consent of the Roads Committee to prepare plans for a depôt, there being no adequate accommodation for the carts and plant, and the stabling being unsatisfactory. In February 1898 the plans were approved by the Council and application was made to the Local Government Board for sanction to a loan of 1500*l.* Inquiry was held in October 1898, and sanction received in November 1898. The work was commenced the following February, and completed by midsummer 1899, at a cost of 1500*l.*

The accommodation comprises stabling for nine horses (including loose box) with loft over, office, harness room, cart

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sheds, blacksmith's shop, wheelwright's shed (and shop over loose box) house for foreman, steam-roller house, urinal, etc. The old corrugated iron roller shed is placed in one corner of the yard and used as a cement store.

The gas-holder is the last remaining portion of the old gas-works which occupied this site.

Public Buildings.

The principal Corporation property consists of Municipal buildings (erected 1876, with the exception of the old town-hall) comprising a council-chamber, police-court, town-hall, committee rooms, retiring rooms, offices for surveyor, and care-taker's apartments; corn exchange (having a floor space of 160 ft. by 50 ft.), the technical institute, cattle-market, and a considerable number of cottages.

Infectious Diseases.

The Council erected in 1896 a corrugated iron hospital on an isolated site about two miles from the centre of the town. This has, up to the present year, met all requirements. As the Rural District Council has now joined with the Corporation in providing "joint" accommodation, four more wards have just been added, so that the new hospital contains: two nurses' rooms, kitchen and scullery; six wards, two for scarlet, two for typhoid, and two for any other disease (except small-pox) which may require isolation.

In addition to adding the four wards, the whole buildings have been moved bodily about 150 yards to another portion of the site, and joined on to the new buildings so as to be in a better situation as regards light and air.

The total cost of the whole place has been 975*l.* *plus* 68*l.* for removing the old buildings.

Fire Brigade.

The borough is fortunate in possessing a highly efficient amateur fire brigade, which is subsidised by the Corporation to the amount of 42*l.* per annum and the rent of the fire station. The brigade possesses a new Shand Mason steamer with all accessories.

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Open Spaces.

The town is surrounded by four commons which are within half-an-hour's walk of the centre of the town. In addition there are four open spaces available for recreation, but which cannot be laid out in any way owing to the fact that there are commonable rights attached to each. On April 29 last, an inquiry was held at the Town Hall into an application by the Corporation to borrow the sum of 1000*l.* for the purpose of laying out a portion of the farm which was bought in 1893 for sewage disposal, but which has not been used for that purpose. The result of the application is still awaited.

Swimming Baths.

There are two open-air swimming baths owned by the Corporation, with dressing-rooms and appurtenances. The paying bath is 160 feet by 40 feet and the free bath 80 feet by 40 feet. The income from the paying bath is about 40*l.* per season.

Water Supply.

The water supply is in the hands of a private company. Samples are taken for chemical and bacteriological examination twice a year, the result being highly satisfactory. The water, however, is very hard (24° Clark's scale).

Bye Laws.

Building bye-laws based on the Model bye-laws were made by the Council in 1896; there are a few old special bye-laws in force.

Drainage of the Village of Donnington.

In March 1900, the Author was asked by the Rural District Council of Newbury to prepare a scheme for dealing with the drainage of the village of Donnington, situate just outside the borough boundary, the total flow to be dealt with being about 3000 gallons per twenty-four hours. Plans were prepared showing sewers gravitating to a chamber at the lowest point of the village, containing two Shone ejectors of 50 gallons

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capacity, the ejectors being worked from a small station within 20 yards of the chamber. The scheme was approved by the District Council and the Local Government Board, the work being completed by Christmas last, at the cost of 2000*l.* The sewage is ejected through a rising main 760 yards in length, 5 inches in diameter, into the nearest point of the Corporation system. The plant consists of one 5-B.H.P. gas-engine-air-compressor, with wrought-steel air-receiver (8 feet 6 inches high by 2 feet 6 inches diameter) coupled to one Shone ejector of 50 gallons capacity. Owing to the difficulty of procuring a site for a compressor station, the Council had to accept the present one, which is extremely small, there being insufficient room for a duplicate installation.

General.

All works of sewer extension, road-making, paving, repairs to property, etc., are executed by direct employment of labour; the Council, on the recommendation of the Author, having recognised that for these works this method of procedure is the best and cheapest. Works involving the erection of new buildings, e.g. the depôt, house at pumping station, etc., have been let by contract. Plans have been prepared for workmen's dwellings; but this matter is still in abeyance.

Supplementary.

Result of Analyses of two Samples of Sewage Effluent and one sample of Sewage received from Newbury, July 23rd, 1902.

Sample of Sewage marked "No. 1."

Borough of Newbury, Outfall Works. Date taken, July 21st, 1902. Taken by A. E. Bosley (Works Manager).

Sample of crude sewage. Time, 1.50 P.M. Wind N., weather fine.

Analysis	Parts per 100,000.
Free ammonia	8·48
Alb. „	1·572
Nitrogen as nitrates	0·0000
Equal N2 O5	0·0000
Solids in suspension	43
„ in solution	85
Oxygen absorbed in 4 hours at 80° F.	11·52

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SAMPLE OF EFFLUENT MARKED "No. 2."

Date July 21st, 1902. Taken by A. E. Bosley.

Sample of Effluent from No. 4 Bac. Bed 2 hours' contact.

Time 4 P.M. Wind N., weather fine.

Analysis.	Parts per 100,000
Free ammonia	5·4
Alb. „	0·265
Nitrogen as nitrates	a trace
Equal to N2 O5	a trace
Solids in suspension	2·9
„ in solution	61·1
Oxygen absorbed in 4 hours at 80° F.	2·07

SAMPLE OF EFFLUENT MARKED "No. 3."

Sample of Effluent taken from main outlet previous to entering stream.

Time 5 P.M. Wind N., weather fine.

Analysis.	Parts per 100,000.
Free ammonia	3·63
Alb. „	0·049
Nitrogen as nitrates	0·81
Equal to N2 O5	3·124
Solids in suspension	1·1
„ in solution	64·9
Oxygen absorbed in 4 hours at 80° C.	0·504

Comparison.	All in parts per 100,000.		
	No. 1.	No. 2.	No. 3.
Free ammonia	8·48	5·4	3·63
Alb. „	1·572	0·265	0·049
Nitrogen as nitrates	nil	a trace	0·81
Equal N2 O5	nil	a trace	3·124
Solids in suspension	43	2·9	1·1
„ in solution	85	61·1	64·8
Oxygen absorbed in 4 hours at 80° F...	11·52	2·07	0·594

Sample No. 2 had a slight odour of sewage. Sample 3 none.

The decrease of albumenoid ammonia is considerable in No. 2, but the peculiarity is the absence of nitrates. The nitrogen is apparently eliminated, on the subsequent action shown in No. 3, the remaining nitrogen is partly eliminated and partly converted into nitrates.

J. BRIERLEY,

Public Analyst for Southampton and Newbury.

Note by Editor.] *Oct. 17th*, 1902.

MR. VINCENT writes as follows:—

". . . . On the occasion of the visit of the Association in May last, the President (Mr. Mawbey) was kind enough to advise me to alter the method of filling and aerating the bacteria beds, so that the effluent therefrom might be improved.

"His recommendation was that the beds should be changed three times in twenty-four hours instead of four times, and that each bed should have one day of rest per week.

"The Analyst's Report (as above) shows that this recommendation has proved most beneficial. . . . ."

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THE NEWBURY GAS UNDERTAKING.

By W. R. DAVEY, Manager.

The borough of Newbury, up to the time of the extension of the boundaries in 1878, was supplied with gas by a limited company. At that time this Corporation purchased the works and mains for the sum of 10,000*l.* The make of gas was about 12,000,000 cubic feet per annum, the price being 7*s.* 6*d.* per 1000 cubic feet. Notwithstanding the high charge made for gas, it was evident the demand would increase beyond the capacity of the works, which were somewhat obsolete and quite inadequate to an increase of business. In the year 1881, therefore, the Corporation determined to purchase the present site, which comprises an area of about two acres, and constructed new gas-works thereon, and, at about the same time, enlarged the district mains. The consumption of gas continued to increase steadily, and in the year 1892 the gas produced was 27,971,000 cubic feet, the selling price being 4*s.* 6*d.* per 1000 cubic feet, the capital account having increased in the meantime to 25,000*l.*

In the year 1893 a further capital sum of 3000*l.* was raised for the extension of the retort house, coal stores and gas-holder, making a total capital at the date 28,000*l.* in addition to a sum of 8000*l.* which had been written off out of profits on account of the abandonment of the old gas-works.

The gas consumption continued to increase steadily until the year 1900, when the Author obtained the consent of his Committee to introduce the prepayment gas meter and the hiring of gas cookers, the price of gas being reduced from 3*s.* 11*d.* to 3*s.* 6*d.* per 1000 cubic feet net. From this period the real progress of the gas undertaking commenced, as the make of gas since that date has continued to increase concurrently with larger profits and a further reduction in the selling price.

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The statement appended below will concisely show the progress made:—

Year ended March 31.	Coal Carbonised	Gas made.	Net Selling Price.		Gross Profit.	Net Surplus Profit.
			Private.	Corporation.		
	Tons.	Cubic feet.	s. d.	s. d.	£	£
1899	3032	34,419,000	3 11	2 4	1738	364
1900	3508	37,686,400	3 6	2 4	2350	1000
1901	3879	41,957,000	3 4	2 4	2659	1224
1902	4159	45,236,000	3 4	2 4	2559	1000

From June 1900 to March 31, 1902, 408 new prepayment consumers were added to our rental, 393 of whom have cooking stoves attached, and, in the same period, 81 additional ordinary consumers have been acquired, and 150 cookers have been supplied to the customers in this class.

The Local Government Board declined to grant a loan for the purchase of gas cooking stoves, although the application made at the same time for money to provide internal fittings was acceded to. The Council have therefore paid for the gas cooking stoves out of the surplus profits, and have also paid for the installation of retorts (described hereafter) from the same source, the work being a reinstatement of plant demolished some few years ago.

The capital charge on the Gas Department account is 30,500*l.* less the sinking funds and the loans paid off, which amount to 7032*l.*

The public lighting of Newbury is carried out by the Gas Department, to whom the Lighting Committee pay the sum of 2*l.* 15*s.* per lamp per annum, which includes the cost of gas, labour, lighting etc., renewals, and repairs, also the interest on capital expended on lamp-columns, lanterns, etc.

The district is lighted with—

14	C. Incandescent burners of	50 candle-power each
75	No. 4 Kern „	80 „ „
2	Welsbach intensified burners and lanterns	300 „ „
200	Common flat-flame burners	
291		

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Construction and Working of Regenerative Retort Settings.

The economy resulting from the application of well designed gas producers and regenerators to the heating of coal-gas retorts is no longer doubted, and the subject will continue to force itself upon all gas manufacturers until the system is universally adopted, it being applicable to the smallest as well as the largest gas-works. The aim of the gas manufacturer has been to recover as much as possible of the cost of the coal employed, by the sale of the residual products, such as coke, tar, ammonia; and during the past twenty-five years probably no improvement in the manufacturing process has contributed more to the realisation of that result than the gas producer and regenerator system of heating the retorts.

The gasification of the fuel in the producer, and the subsequent addition to the combustible gas generated therein of a supplementary and regulated supply of air, previously heated to a considerable temperature by the waste heat of the settings on its way to the chimney, will commend itself to the judgment of all interested in the subject, it being in accordance with the principles of science and economy, the saving effected being that which results from the application of exact science as against ordinary practice.

The saving of fuel alone under the regenerative as compared with the old system of firing is an important item, equal to 25 to 35 per cent. of the coke produced, according to the quantity of coal used and the efficiency of the common or direct-fired furnace, besides a larger yield of gas per ton of coal carbonised, amounting in many instances from 200 to 500 cubic feet per ton, whilst the gas is generally improved in quality.

The temperature of the retorts is under better control, and may be varied in order to obtain the best results from the particular class of coal to be carbonised.

The working of the regenerative settings recently installed at the Newbury Gas-Works has given entire satisfaction, and the following comparison between the new and old methods will show the saving effected.

As prices vary in different districts, the writer has only dealt

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with quantities in this statement from which the money values may be calculated if required.

Working Test, 24 hours.

Regenerative Furnaces. 3 ovens, 16 retorts, 9 ft. 6 in. by 22 in. by 15 in. D section.		Common Furnaces. 3 ovens, 21 retorts, 9 ft. 6 in. by 21 in. by 15 in. Oval Section.		
—	Regenerative Furnaces.	Common Furnaces.	Differences.	—
Coal carbonised ..	11 tons 14 cwt.	11 tons 8 cwt.	6 cwt.	Increase
Gas produced (cub. ft.)	128,000	120,000	8,000	Do.
„ per ton	10,940	10,526	414	Do.
No. of retorts.	16	21	5	Decrease
Gas made per retort per diem (cub. ft.)	8,000	5,714	2,286	Increase
No. of furnaces ..	2	3	1	Decrease
Average weight of fuel used per diem	3669·12 lbs.	5529	1859·88	Do.
Fuel used per 100 lbs. of coal carbonised	14 lbs.	21·2 lbs.	7·2	Do.

Construction and Working.

Regenerative settings are of two or three classes, viz. shallow, semi-shallow or deep; the former may have a producer 3 feet below the floor-line, whilst the latter may be 7 or 8 feet deep. The shallow producer is generally adopted where the necessary depth below the floor is not available owing to the presence of water or other circumstances preventing the raising of the floor-line to obtain the height required to install a full depth producer, for which purpose a height of at least eight feet is necessary from the furnace-chamber floor to the charging floor.

Producers were formerly in many cases constructed away from the retort-bench and the gas conveyed thereto by means of a conduit, and burnt under the retorts; but at the present time, and in almost every instance, the producer is placed directly under the retorts. The latter system avoids a large amount of loss of heat by radiation, and enables the producer to be fed with hot coke direct from the retorts, resulting in economy of fuel and a more regular production of gas. The producer,

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in gaseous firing, is that portion of the setting responsible for the supply of carbonic oxide gas necessary to obtain the amount of caloric for carbonising a given quantity of coal per day, and is constructed rectangular in shape, the size depending upon the number of retorts to be heated, the fuel being supported on fire-bars or a hearth, or a combination of both. The settings recently constructed at the Newbury Gas-Works have a producer of the latter type 6 feet 8 inches deep (from the sole-plate to underside of arch) by 2 feet 9 inches by 3 feet 6 inches, which contains, under working conditions, about 40 bushels of coke.

Having briefly defined this part of the plant, the Author will endeavour to give a more detailed account of the method of construction of the retort settings and recuperating flues usually adopted in gas-works. On the drawing is a cross section of an arch, showing the producer, having an iron sole-plate at bottom with fixed horizontal fire-bars curving outwards to the full width of the producer's sides and between which the primary air for the production of carbonic oxide passes. The walls are carried up to the springing of the arch, and are built free from the surrounding brickwork, so that the furnace sides may be renewed without disturbing the adjoining flues. At intervals along the whole length of the arch, and on either side, nostril holes are formed for distributing the furnace gases; it is at this point that the supplementary supply of heated air is brought into contact with the carbonic oxide, and where an energetic combustion takes place, developing an intense heat estimated at 2500° F. This part of the setting is designated the combustion-chamber, and is built of specially made silicate fireclay material. The retorts are supported their whole length on cross walls placed at intervals, and are carefully pinned against the arch to prevent distortion. The heat having been generated in the combustion-chamber is drawn up by the chimney draught to the top retorts and thence down by the outside retorts to the regenerative flues below the floor-line. It is in these flues that the outgoing spent gases part with a great deal of their active heat, which is absorbed by the ingoing secondary air and is conducted back to the combustion-chamber. The ingoing air travels in a contrary direction to the departing spent heat, as shown on the drawing, the secondary air being sandwiched between the spent gas flues and the producer sides and arch the whole length of its travel.

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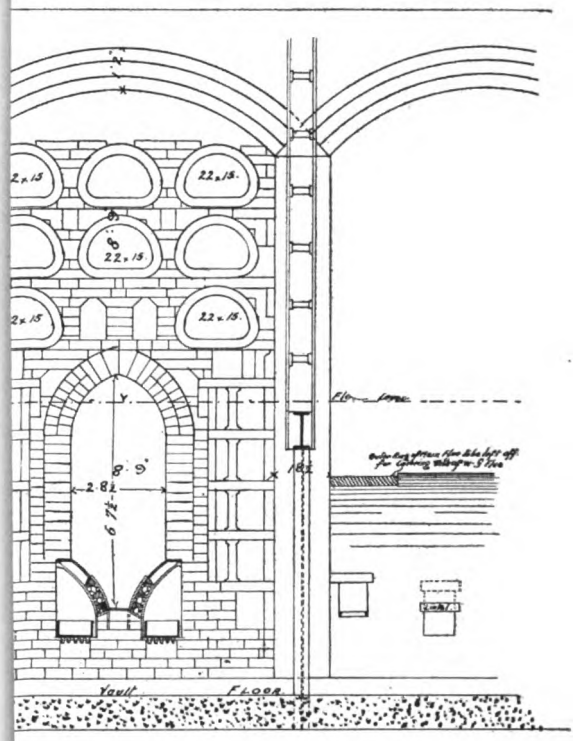

IONAL ELEVATION.

RY GAS UNDERTAKING:

GENERATIVE RETORT SETTINGS.

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On each side of the regenerator, and at the level of the bottom flues, is a damper, which serves to regulate the chimney draught as well as to equalise the heat of the retorts on both sides. Immediately below the fire-bars is placed an iron pan which is filled with water to produce a steady supply of cool steam, which prevents the fire-bars becoming overheated, and assists to disintegrate the clinker, which facilitates the cleaning of the furnace.

Working.

The method of working will be better understood by reference to the drawing.

The producer is charged with incandescent coke to the depth of 5, 6, or 7 feet according to circumstances. A limited supply of primary air being admitted to the grate bars, combustion of the carbon in the coke takes place, producing CO_2. This point is termed the "zone of combustion." From here the CO_2 travels upwards through the incandescent fuel and parts with one of its atoms of oxygen (O); thus we obtain the combustible gas carbonic oxide (CO). This newly formed gas (see Appendix) passes through the nostril holes in arch to the combustion-chamber, where it meets with the supplementary and heated supply of air, and is again converted into carbonic acid, as before described. The secondary supply of air is regulated by means of slides fixed at the air entrance, the openings of which are adjusted so as to admit sufficient air only for the complete combustion of the producer gases; an insufficient supply will cause loss of heat, and the gases will pass away to the chimney unconsumed. This state of things may readily be detected by observing the burning of the gas, which emits a blue flame in the lower flues, when a further supply of air is admitted, through an inspection hole.

It will be observed that too much secondary air has an equally harmful effect, because in this case an excessive quantity will so shorten the flame of combustion, and produce an intense heat so centralised as to be liable to flux the surrounding brickwork, as well as to raise the temperature of the centre retorts too high for carbonising, whilst that of the outside retorts, on the contrary, would be much too low, in the former instance producing large quantities of poor coal-gas with the attending production of solid pitchy matter, which blocks up the ascension and bridge pipes, in the latter condition entailing a

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small quantity of gas and a large yield of condensable vaporous products, which would be a source of loss to the gas manufacturer.

APPENDIX.

ANALYSIS OF PRODUCER GASES BY VOLUME.—*Graham.*

Carbonic acid (CO_2)	5·3
Carbonic oxide (CO)	24·8
Hydrogen (H)	14·8
Marsh gas (CH_4)	3·6
Nitrogen (N)	51·5
	100·0

DISCUSSION.

The PRESIDENT: I was very much struck by the way in which you had followed the advice of the borough engineer and your own good judgment in substituting the bacterial system of sewage for the old precipitation tanks. I have been wondering how it was that the capacity of these beds had been reduced to one-fifth of their total capacity, and thought, perhaps it was because he had not enough money to spend on the works and had been putting crude sewage on the beds, without having any preliminary tanks to deal with the solids. It is very satisfactory to see that you flush the sewers with no less than twenty-four automatic flushing tanks. But there is another thing which I do not think is to your credit, that is, you have a number of open manhole covers in the streets. I must congratulate you upon the result of the purchase of the gas undertaking, because, whereas you used to have to pay 7*s.* 6*d.* per 1000 cubic feet, you now only have to pay about one-half that for your gas. You have been well advised in adopting a system of prepayment meters and of gas cookers. The only other matter for regret is that you have not municipalised the water undertaking.

The MAYOR: We are trying to do that.

The PRESIDENT: I should say when you do that, one of the first things will be to reduce the 24° of hardness to 7° or 8°.

Mr. J. LEMON: I have much pleasure in proposing a vote of thanks to the Authors of these papers. It is some years ago since I was in this room—as long ago as twenty-four years—and on that occasion the Corporation signed my death-warrant.

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The circumstances are unique in municipal history, and I may be pardoned a personal reminiscence. I was asked by the Corporation of Newbury to prepare a drainage scheme for the borough. When I came down to make an inspection of the town I said, "It is a most extraordinary thing to ask me to prepare a scheme when quite half the town is outside the borough boundary. The first thing you have to do is to extend your borough boundary. It is absurd to ask an engineer to prepare a scheme until that has been done." The then Town Clerk —he is now dead—said that was out of the question, because the outside authorities were sure to refuse. He added, however, that I might try, and accordingly I went to the Clerk of the rural authority, who said they were quite ready to come in on terms. The result eventually was that I prepared a scheme for the extension of the borough boundaries. It passed through both Houses of Parliament without opposition, and a new council had to be elected as the new area was so different. Subsequently I prepared the drainage scheme as instructed at one of the first meetings of the extended borough. A councillor got up and moved: "That the question of the drainage of this important borough be adjourned *sine die*." That was duly seconded and put to vote and carried, and, of course, I was done with. I am pleased to see that since then they have made so much progress in the drainage of the town. In reference to Mr. Vincent's paper, I cannot understand how the capacity of these tanks should have shrunk in such an extraordinary way as they have done. The only conclusion I can come to is that no adequate precautions have been taken to intercept the detritus which finds its way to the beds. That is not the fault of the engineer, but the fault of having no intercepting tanks. I notice it is stated that the manholes are lined with tiles at a cost less than that of rendered brickwork. I can only say that I cannot do it, and I would like to know how Mr. Vincent manages it. The cost of the sewerage scheme is stated at 30,000*l*. Of course the circumstances are very much altered now to what they were when I prepared a scheme, but I believe my estimate was 17,000*l*. I notice there is a long line of pumping main which extends to about 2¼ miles. I do not know why the Corporation could not have obtained land much nearer to the town than 2¼ miles. I can only say that I entered into a preliminary agreement for land very much nearer than that, so I am speaking

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of what I know. There is splendid water-power which is utilised by the mills, and I proposed to use that water-power for my scheme. I notice that nothing has been done in that way in connection with this scheme, and that the pumping is done with a gas engine. I would be glad if Mr. Vincent could tell us the cost at which the pumping by gas works out. It appears that the Corporation supply the gas at a very low rate, a preferential rate which really represents the cost of production. I do not blame them for that, as they are certainly entitled to be supplied cheaper than outsiders. I would like to know what the net lift of the sewage is, and what the gross lift is; we should then be able to see the consumption of gas per horse-power. It appears to me that the work is done exceedingly well and cheaply if you are able to lift 27,000 gallons and discharge through 2¼ miles of pipes at a cost of 1*d*. I certainly agree with the President that it is a good thing to find in a small town like this so many as 24 automatic flushing chambers. It is, in fact, an admirable state of things. The management of the gas undertaking is also extremely creditable to the Corporation. They are able to supply gas at a much less cost than the company were able to do, and even then make a profit. In 1878 when I came to Newbury I strongly urged the Corporation to buy the gas-works, and I am glad to say they did, and that the result has been so satisfactory.

Mr. W. Weaver: I have very much pleasure in seconding the vote of thanks proposed by Mr. Lemon. The Association visits both large and small towns throughout the country, but I am sure it is gratifying to the older Members to visit smaller places and see the work being done by their younger energetic brethren who are coming forward in the ranks to take the places of the older Members as they disappear. The only point in the paper I wish to touch upon is the roads. I think it is a mistake to have unchannelled roads. It is more economical and sanitary to have a channel of some kind, and if it is a matter of expense, in a small town like this it is quite sufficient to make a concrete channel, the same as the pavements. I see the only wood paving laid in the town is some karri in front of the Municipal Buildings. I think if the Members of the Corporation wait for their experience of that material before they decide to extend wood paving in the town, the extension will not be with similar wood.

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Mr. W. HARPUR: I think Newbury is to be complimented upon having such an able surveyor and one who has done such good work as Mr. Vincent. The fact that the Corporation since the purchase of the gas-works has been able to supply gas at such a reduced price is an item which we can take home and preach to our councils. In every town we have gentlemen who are advocates of contract or company work for everything and disapprove of municipalisation; but here in Newbury we have an undoubted case where the municipalisation of the gas-works has proved to be a benefit, for while the consumers have got their gas cheaper the town has also benefited very considerably. I notice, in the matter of street paving and repairs, Mr. Vincent has found he can do the work better and cheaper than by contract. I think it is preferable that corporations should carry out their street work departmentally rather than by contract. You may be sure of having the value of the money you expend when you carry out your own work, and that cannot always be said of contract work. While contracting may be right and proper in many instances, in the maintenance and repair and breaking up of streets I have the very strongest opinion that it is best for the authority to keep that class of work in its own hands.

Mr. W. N. BLAIR: What struck me on reading the paper was the comparatively low cost for which a considerable amount of work has been done. An item that particularly attracted my attention was the works depôt where the accommodation set out in the paper was provided for the comparatively small sum of 1500*l*. Not having had the opportunity of inspecting the building one cannot say more, but in other points also there appears to be very considerable result from a small expenditure. I concur with what Mr. Weaver says as to the importance and great value of having a paved and impervious channel in every street. It may be a matter of some small cost, but it is of great importance in preventing the percolation of foul matter into the ground. Where the streets are narrow and without channels, some of the houses may get a filtration of this offensive matter into the cellars and walls. That should not be allowed to occur. I should like to have some little explanation of the remarks which Mr. Weaver has made in reference to the use of karri wood paving. He says, if they wait for their experience of karri wood paving they will not extend the use of hard wood paving. His observation may

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be interpreted in two ways, but I presume that what he means is that they will have to wait so long before any result is visible, that they will be precluded from using any more. The amount of wear that this hard wood will stand, especially in a town like Newbury where the traffic is very light, is simply enormous. Naturally, where you get an exceedingly heavy traffic such as in London, the result is different, and a measurable amount of wear may be seen in a few years. If, on the other hand, Mr. Weaver is adverse to hard wood generally I do not follow his reasoning, so perhaps he will be good enough to say something further on the question. Great credit is due to the Corporation of Newbury for their efficient management of the gas-works and for having increased the output from 12 millions to 45 million cubic feet. At the same time they have reduced the price from 7*s.* to 3*s.* 4*d.* per thousand cubic feet. The question arises in my mind whether the price charged to the Corporation itself is actually up to prime cost; because, if the price charged to the Corporation is less than the cost of manufacture the price is proportionately raised to the private consumers. If that is so it is not justifiable. Everybody in the district does not take gas; and obviously in the interest of the Corporation works they should be induced to do so. If you keep up the price to the ordinary consumer by unduly reducing the price to the Corporation you are retarding the use of gas among private consumers. I do not know much about gas production, but it is obvious from the paper that the result of the use of these regenerative furnaces is remarkable.

Mr. W. WEAVER: Certainly I am adverse to the use of karri wood paving. I do not think the town will find that the paving will wear out; that is not the fault. The present paving has been down for two years, and if the Members will look at it as they go out of the building they will find that the cross joints in the wood are already open to the extent of $\frac{1}{3}$ inch, and this shrinkage is the invariable fault of karri wood. Before that paving has been down for four years it will be as bad and noisy to drive over as a granite sett road. This has been my experience of it, and I have taken up some thousands of pounds' worth of jarrah and karri which had not been down six years. In the Westminster Bridge-road, which was laid by Mr. Macintosh, the hard wood lasted ten years and the creosoted wood two years longer, though the hard wood paving cost very

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much more. I consider it desirable, after the speech of Mr. Harpur, that I should make some further remarks on the subject of municipal *versus* contract work, because otherwise it might be assumed that every borough surveyor is of opinion that municipal labour is preferential to contract labour. I have had forty-two years' experience of both kinds of work, and my experience is that if you do your own work you can get it done better; but as to cost, municipal work will not compare favourably with contract work. Not that the cost of a particular job will not come out favourably, but you want to take the cost of the whole of the work all the year round. The great danger of municipal work is that the borough surveyor gets saddled with a body of men he cannot discharge, and work has to be made for them, and the expenditure goes up in consequence. Every man has a vote at the elections and it is difficult for the surveyor to discharge men belonging to societies influencing the election of his masters. I remember a case of a man who came to me with a letter which said, "Cannot you find this man a job, he has been for forty years in my family as a gardener." I wrote on the back of the letter, "After forty years' service in your family do you not think you can find a job for him yourself?" He brought it before the Board and said he thought it was rude. I thought it was a very proper reply to an improper request.

Mr. J. H. NORRIS: With reference to the drainage of Donnington, I should like to ask what arrangements are made for payment by the local authority. Also I should like to know whether Mr. Vincent has found any difficulty as regards the construction of an absolutely separate system for sewage and storm water in connecting up old houses, and in the case of new houses whether he always succeeds in getting an absolutely separate connection made.

Mr. A. J. DICKINSON: I should like to ask if the 1½-inch gauge granite used on the roads withstands the effect of frost. As a rural surveyor I have had to increase the gauge of the stone to 2 inches as I find the 1½ stone picks up with the frost. Therefore I have found it advisable to increase the size of the stone.

Mr. J. MANLEY: I should like to refer to the use of different materials in the side streets to that used on the main roads. I notice that the Clee Hill granite is used on the main roads and local gravel on the other streets. I should like to know whether

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that is an economical proceeding or not. I question whether the practice is a wise one, and perhaps Mr. Vincent, with the experience which he has had of it, will tell us whether the material which best satisfies the county authority for main roads would not also be best for other roads.

The PRESIDENT: I will put the vote of thanks and ask you to pass it very heartily. It is evident to me that this paper has given you very great satisfaction, and I have no doubt the works will afford equal gratification. I must support Mr. Harpur in his contention as to the great advantage of doing work departmentally. Mr. Harpur is not afraid of doing work with his own staff, because he has already carried out large schemes by direct labour, including the construction of a tramway system for his borough. In Leicester we are spending 650,000*l.* on a tramway scheme, which is to be largely carried out by direct labour. I cannot go so far as Mr. Weaver as to the question against hard wood, but there is no doubt a great deal in what he says about shrinkage. We have had a very good experience in Leicester with hard wood, where it has stood very well throughout. Therefore we must not take Mr. Weaver's view too seriously, but try to avoid difficulties as far as we can.

Mr. VINCENT, in reply, said: I thank you very much for the vote of thanks which you have passed, and personally express my pleasure that the Association has paid a visit to Newbury. As regards the diminished capacity of the bacteria beds to which reference has been made by the President and Mr. Lemon, there is no doubt they have gone back to one-fifth of the total capacity. That is accounted for in this way: that we have used gravel sifted from the site instead of any more porous material. Secondly, we have not done anything whatever in the way of primary beds, but have put the crude sewage on to the gravel beds. We have made experiments with troughs for distributing the sewage over the beds, but have abandoned this system because they were too much trouble. The Members, when we visit the works, will see the method adopted. These points explain why the working capacity of the beds is down to one-fifth of the total capacity; I may say it has stood at one-fifth for some months, it is not getting less. I am satisfied that the shrinkage is not going on, and that the beds are not sludged up. As regards the open manhole covers to which the President has referred, we are abolishing them a few at a time. They are an

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unmitigated nuisance, and every time we can obtain permission from an owner of property to put up a shaft, we close the nearest open manhole cover. I think the experience of many surveyors is that that is the best course to pursue. We can line the manholes with glazed tiles at a slightly *less* cost than that of rendered brickwork. We get an excellent shingle at from 2*s.* 2*d.* to 2*s.* 6*d.* per cube yard. As regards the rising main, the level of the outfall works tanks is the same level as the top of the receiving well at the pumping station. There is no net head. The friction head is 17 feet, the lift 16 feet, total 33 feet. The cost of 1*d.* per 2700 gallons is for gas only. As regards the gauge of granite we use for repairing the roads, I have used a good deal of 2-inch, but the 1½-inch makes a better road. We scarify the roads first and the 1½-inch gauge rolled with a 10-ton roller makes a very good road. Channelling I am much in favour of, and the Council have commenced channelling in certain streets. There is no doubt that a channel is absolutely necessary in every road. The concrete footpaths we do ourselves. The reason of the low cost of the work here is that we generally get cheap and good labour—men we are able to rely upon. It is a capital district for labour. The 1500*l.* for the depôt is exclusive of the cost of the site, it is for buildings only. The site belonged to the town. The karri wood is outside to speak for itself. I do not think I shall be here to see it wear out. The Corporation receive a payment of 50*l.* a year for admittting to their sewers the sewage of Donnington, for a maximum of 30,000 gallons per week. We have not yet a separate system of sewers for the whole of the town, that will come in time. Where we drain new houses we have to see that some means are provided for dealing with rain water, and if we cannot do more, we allow a soak-away to be constructed. We carefully exclude the whole of the rain water from the sewers.

The Members attending the Meeting then proceeded in brakes to inspect the pumping station and outfall works, where the bacterial treatment of sewage is in operation, the Gas-works and the Corporation depôt.

Upon returning to the Town Hall, tea was provided by the kindness of Mr. Vincent, to whom a hearty vote of thanks was accorded.

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DISTRICT MEETING AT WOLVERHAMPTON.

June 14, 1902.

Held in the Drill Hall, Stafford Street, Wolverhampton.

E. GEORGE MAWBEY, M. INST. C.E., PRESIDENT, *in the Chair.*

THE Members were received and cordially welcomed by the Mayor (Mr. C. P. Plant).

The President thanked the Mayor for the hearty welcome accorded to the Association, and spoke of the great value derived both by Members attending these meetings in the interchange of information and the authorities represented.

He felt it an especial privilege to visit Wolverhampton, having regard to the magnificent Exhibition being held there and the novel system of electric traction which would be inspected that day. The courage of the corporation in carrying out this experiment, deserved the thanks of municipal authorities throughout the kingdom.

WOLVERHAMPTON CORPORATION ELECTRIC TRAMWAYS, 1902.

BY GEORGE GREEN,
BOROUGH ENGINEER, WOLVERHAMPTON.

IN reading a paper upon the subject of Tramways, the Author is painfully aware that he is dealing with a somewhat hackneyed subject—at all events, as far as track-construction is concerned. He cannot hope to introduce to his hearers much, if anything, that is novel, although the tramways which are the subject of this

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paper, are being laid on a "Surface Contact System," both original and novel, no similar system being laid in this country.

The system being laid in Wolverhampton is known as "The Lorain Surface Contact System," and whatever may be its ultimate position in the ever-growing development of tramways in this country and the world at large, it must be granted that the Corporation have shown considerable "pluck" and the patentees great enterprise in embarking upon such a great and important experiment.

In this paper the Author intends to confine himself to a brief description of the track work, leaving to more able hands the more interesting part of the subject, viz., the equipment of the "Lorain" system, for which the Association is indebted to the Borough Electrical Engineer, Mr. C. E. C. Shawfield.

While it must be admitted that this paper is necessarily of secondary interest, it is to be hoped it may serve the useful purpose of exposing some of the difficulties that have to be met with and overcome in all new systems.

In all fairness to his predecessor, the Author must commence by explaining that the scheme of tramways now being treated upon was designed by the present City Engineer of Westminster, and the contracts were actually let and commenced before the Author took charge of the work.

Date of Act.—The Act of Parliament authorising the construction of electric tramways in Wolverhampton was passed in 1899.

Length of Track.—The roads embraced cover some 23½ miles of single track.

Cost.—The estimated cost amounts to over 210,000*l.* (two hundred and ten thousand pounds).

The track at present constructed is about 11½ miles (single track). Of this length the Board of Trade has certified some 5½ miles (single track).

Curves and Gradients.—The sharpest curve upon the line is laid to a radius of 37·6 inches to the inner rail, and the steepest gradient is 1 in 17 for a distance of 100 yards.

Street Lines.—Many of the streets through which the tramways pass are thoroughly English in design, inasmuch as they are inconveniently narrow in width, picturesquely irregular in line and curve, with the usual artistic disregard of proper angles and levels.

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While these characteristics develop the patience of the engineer, they also add considerably to the cost of the undertaking, and to the profits of the property owners who are fortunate enough to possess premises in such streets.

Improvements.—Tramways in this country must always be more or less handicapped by having to bear the burden of such necessary street improvements, though it is only right that this should be so, seeing the large amount of street surface they monopolise. Street improvements, involving large sums of money, are being carried out over and above those included in the Act.

Construction of Track.—One of the circumstances in connection with the construction of the permanent way in Wolverhampton which deserves notification, is the fact that practically the whole of the tramways have been constructed in streets, the carriageways of which were at the time of commencement macadamised. This, of course, added not only to the cost of construction, but also to the length of time the works have taken to complete.

The lines are, for the greater length of the track dealt with, laid as double lines, the single track only being laid in a road outside the borough, with the consent of the local authority concerned.

The old macadam has been used, as far as possible, for the concreting of the foundation, after being sifted and cleaned, the contractor allowing a sum per super yard, where the macadam has been used for this purpose. While this has somewhat cheapened the cost of construction, it has also caused some inconvenience to the public, as the material had to be riddled and sifted in the various streets, as the work proceeded.

Rails.—The rails, which weigh 91 lbs. to the yard, are in 60-feet lengths, and have been supplied from the Leeds Steelworks. These were laid upon 6 inches of cement concrete mixed 6 to 1; sand being added to the old macadam in a proportion of 2 to 1 of cement.

Joints.—The joint used is known as the "Victor" joint, being bolted, not only through the "web" of the rails, but also to the flanges. The Author does not wish to express any opinion upon this joint, but is simply stating a fact.

Tie-bars, 2 in. by $\frac{3}{8}$ in. by 4 ft. 6 in. long, are fixed every six feet, and the rails are treble bonded at every joint by one "Neptune" and two "Columbia" bonds.

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The whole of the rails have been tested at the works by an Expert, on behalf of the Corporation, before being delivered on the track; so have the points and crossings made in England.

The American goods were not examined until delivered in this country.

Special work.—Some of the points and crossings used for the special work have been supplied by an English firm, and the remainder by the Lorain Steel Company, of Johnstown, Ohio, U.S.A.

While anxious to say all that is possible about English workmanship, the Author cannot help expressing his regret that that supplied from this country was not so well designed or as accurately and truly constructed as that procured from abroad. It must be admitted, of course, that the cost of the American work is considerably higher than the English, but the difference is probably balanced by the saving in cost in fixing the former as against the latter, and the fact that short lengths of rails are cast into each crossing, enables the jointing of rails and crossings to be made in the best manner. This may be somewhat owing to want of experienced platelayers, but the same men were able to lay out and fix the Lorain work in at least a third of the time that they took to put together the English-made work. Rapid construction is, of course, of considerable importance in large towns, where interruption of traffic is of serious importance.

No very complicated junctions occur on the present system, but two of the sharpest curves, viz. Darlington Street by Waterloo Road, and Waterloo Road by Newhampton Road, also occur where the gradients are steepest. As far as possible the outside and inside rails at these points were kept level. It would have been an advantage to have laid the inner rails slightly lower if the cross-fall of the road had not prohibited it.

The Author is strongly of opinion that all special work should be obtained before the main track is commenced to be laid, and that it should be laid, if possible, previous to the straight track.

It should also, without exception, be accurately laid out, and put together, either at the works, or, better still, on an open space near to the track, in order to ascertain that every part is exactly to drawing.

Paving.—The paving of the track, for its greater length, consists of 5-inch by 3-inch granite setts. In some cases 4-inch by

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4-inch granite cubes have been used to harmonise with the existing paving, and on steep gradients, in one or two cases, a grit sandstone York sett (4-inch by 4-inch) has been used; and in one case, chilled steel blocks have been laid alternately with the courses of setts in order to prevent ruts being worn (against the tram-rails) in the sandstone setts.

In some portions of the track wood paving has been laid. This consists of two kinds, viz. red gum and prismatic oak.

Without drawing any comparison between these woods and other woods generally used for paving purposes, and while reserving any opinion upon them for paving purposes generally, the Author is bound to admit that he has not had any trouble with "expansion" or "contraction" of these materials.

The use of prismatic oak seems to possess an advantage over many woods with regard to "expansion" and "contraction," as it appears to be quite stable, each block containing its own expansion and contraction room; but it is very difficult to cut the blocks so as to fit round curves, and in any other part of the track which is not straight.

The Author had no choice in these materials, as they were purchased previous to his coming upon the work.

Surface Contact Boxes.—In connection with the paving there comes in this system the fixing of the "surface contact boxes" which are placed every 10 feet, exactly in the centre of the track, and consist of stoneware cases about 14 inches by 10 inches made of what is termed "reconstructed granite"; the boxes are so fixed that the rims or edges come about the same height as the top of the granite setts. Care had to be taken in paving round these boxes, as it was most important that no setts should be higher than the top of the boxes, otherwise the skate would press upon them, and quickly wear away.

It should be stated that more than half of the track was constructed and paved before any of these boxes arrived in England, and a certain amount of the paving was found to be too high in places to allow the skate to glide evenly over it.

It would have been much more satisfactory if the boxes could have been laid at the same time, or rather just previous to the paving, to avoid a difficulty of this kind arising. There is no doubt the appearance of the track, to a certain extent, suffers because this was not possible.

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There are, no doubt, many persons who do, and will, object both to the appearance and projection of these boxes in the paving. Those who do not mind the appearance must admit that they cause some slight jarring when driving over them. It is, after all, only a question whether they are more, or less, objectionable than the overhead trolley.

In granite sett paving on a road with the usual amount of dirt upon it they are hardly discernible, but they show somewhat more in a wood-paved street in ordinary use.

The Author believes the boxes will be improved, both in the nature of the material of which they are constructed, and in the manner of laying, so as to be more durable and less conspicuous.

It would be advisable to protect the edges of the boxes from traffic.

The paving between the boxes should be kept as smooth as possible to prevent wearing the skates away.

In a wider track, say 4 feet 6 inches, where the camber of the paving is greater, boxes would not be so conspicuous.

There have been no complaints from the travelling public with regard to the boxes, up to the time of writing this paper, and some have been laid in certain streets for over five months.

It might be mentioned here that the cable for supplying the current to the boxes is laid in the centre of the 3-foot 6-inch way, and has been laid in the manner usually known as the "Callender" solid system, in wooden troughs surrounded by bitumen.

As the exact position and height of the surface contact boxes had to be accurately fixed before the cables were laid, it was important that the gauge and levels of the rails should be exactly determined before this was done, and the foundation concrete of the track constructed. Thus there was no possibility of altering the curve line, or height of the rails, after the cable had once been fixed, without considerable inconvenience. Consequently extra care and forethought were necessary.

As has been before mentioned, the gauge of the track is 3 feet 6 inches, and the clearway 4 feet 6 inches in width.

Unfortunately, a considerable portion of the tramways was laid in the winter, and a good deal of interruption was caused

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by the rain, snow and frost. The work somewhat suffered from these latter causes, and the Author suggests that, if possible, track work of this kind should not be constructed in the winter.

Car shed.—A car depôt in connection with the scheme has been built at a cost of between 12,000*l.* and 15,000*l.* to accommodate fifty cars.

This building is not of an ornamental nature, but, it is hoped will answer the purpose required of it for many years.

The outside dimensions of the building are 124 feet wide by 173 feet long and 20 feet high to the eaves.

It is built of red bricks, with terra-cotta facings in the front elevation, and is covered in with an iron and glass roof.

In the basement it contains a large workshop for the repair of cars, and each line of track has under it, for a certain length, a pit 5 feet deep by 2 feet 10 inches wide, lined with white glazed bricks, for the purpose of repairing and examining the cars when required.

In addition to the above, there is office accommodation for the tramways Manager, with the necessary lavatories for the men, together with a messroom. A heating chamber is provided for the drying of aprons, and other necessary details.

A 5-ton electric travelling crane is also provided. It might be mentioned that the contract for the erection of the car shed was carried out by a local firm. The contract for the permanent way was also done by a local contractor.

It should be stated that the Corporation, until the eleventh hour, intended installing the overhead trolley system, and, before arriving at that decision, visited Paris, and inspected all the known systems at that time working there and in this country. Great, therefore, must have been the attractions offered by the "Lorain" system to suddenly change the opinion of the Council, and, without expressing any opinion for or against the wisdom of such change, the Author feels compelled to admire the enterprise of the Council for striving to obtain a system which it is hoped will possess all the advantages of the overhead trolley, without its objectionable elements.

There is a point in favour of the surface contact system which though of minor importance is worthy of note, namely that the cars pass along the street with much less noise than on the overhead system.

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As a public official, the Author desires it to be distinctly understood that he ventures no expression of opinion upon the system now under trial, first: because his position renders such an expression undesirable until the trial period is ended; and secondly, because the short time the system has been working is insufficient to form any correct idea of its possibilities.

One thing, however, is evident to all, viz. that, providing certain difficulties (mostly in details) can be overcome, there is the strongest hope that in the near future, some system will be introduced that will strike a blow at the disfigurement of our cities and high roads, and at the same time tend to develop the enormous network of electric traction which is so rapidly joining town to town, and adding to the convenience and comfort of the people.

SHORT DESCRIPTION OF WOLVERHAMPTON CORPORATION COLD STORAGE AND ICE FACTORY, 1902.

THE question of providing cold stores and the supply of ice-making plant has been under the consideration of the Corporation for a number of years, and, after repeated reports, a scheme was decided upon in 1899.

The sanction of the Local Government Board was obtained in July 1901.

All the drudgery of the scheme—if the stage of reporting, estimating, preparing numerous preliminary plans, etc., and piloting the same through the Council and the Local Government Board may be so called—was performed by the Borough Engineer for the time being, Mr. Bradley, now City Engineer of Westminster, the Author's predecessor.

The Council were committed to the site and general plan, therefore the Author had no choice but to work out the details and complete the scheme as now erected.

It may be mentioned that the cold stores are part of a larger scheme comprising a covered wholesale market, upon an

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adjoining site, now being designed, the total estimated cost of the whole being £23,300 (twenty-three thousand three hundred pounds) exclusive of site.

Capacity of Stores.—The Cold Stores, the site of which provides for future extension, at the present time comprise five cold-storage rooms, having a cubic capacity of 16,650 feet. One of these rooms is intended to be kept at a temperature of about 35 degrees; the other four at 22 degrees.

In addition to this, there is an ice cellar with a cubic capacity of 3750 feet.

Motive Power.—The motive power for working the air-cooling apparatus, and also for manufacturing the ice, is electricity, supplied from the Corporation mains.

It was thought undesirable to erect boilers and a chimney shaft in this portion of the town, and arrangements were made with the Lighting Committee to supply the power at 1*d.* per unit.

For a small installation such as the present one is, this seems to be a satisfactory arrangement, inasmuch as when the storage is very low, and the demand for ice very small, the least possible power would be wasted, whereas with a steam or gas engine, power would be running to waste.

Ice Manufactured per day.—The ice-manufacturing machinery is able to turn out 10 tons of can ice per day of 24 hours, and the cellar will store 90 tons.

The reason for adopting the system of can ice as against block ice is because the ice will be used entirely locally, and be more convenient to use in that form.

Plant.—The plant has been supplied by the Linde British Refrigeration Co., and consists of—

Two compressors.
One surface evaporating ammonia condenser.
One ice tank, complete with necessary moulds.
One filling tank.
One thawing-off tank.
One overhead electric travelling crane.
One air-cooler, with fan, and the necessary motors.

Compressors.—The compressors are horizontal, double-acting and belt-driven, the larger one is generally used for ice making and the other for the cold stores.

It has been arranged that the compressors can be used either

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for ice making or for cooling the air for the cold stores, in order that if a breakdown were to occur to one of these machines, the other one could be used for the more important purpose for the time being, as it will be seen that it is always important to keep the stores going; but it would not be essential to manufacture ice for a short period, when only one of these compressors was serviceable, besides which there would possibly be sufficient ice in store to tide over a breakdown.

Ammonia Condenser.—The ammonia condenser is of the "surface evaporating type," and consists of a series of coils of special lap-welded wrought-iron tube, wound each in one length, so as to avoid inaccessible joints.

It is fixed on the roof of the machinery room, over a concrete tray lined with asphalte, and the whole is surrounded with Venetian shutters, to prevent the spray from being scattered.

Air-Cooler, with Fan.—The air-cooler consists of a series of coils of special lap-welded wrought-iron tube, similar to those used in the condenser.

The evaporation of the ammonia in the coils is utilised for cooling the air, the surface of the coils being kept free from snow by means of a constant "drip" of uncongealable brine, the brine being circulated by a brass-fitted pump, worked by a separate motor.

The fan, provided for circulating the air over the coils, is placed in a duct, and the air is drawn in by the fan at one end and passed out at the other end, after being cooled, shutters being fixed in each store at convenient places to let in the cold air in such quantities as may be required from time to time. The fan is driven, like the other machinery, by an electric motor.

Ice Tank.—The ice tank consists of a brine tank of rectangular form, made of wrought-iron and fitted with refrigerating coils and special lap-welded wrought-iron tubes, made in a similar manner to the other tubes.

The tank contains 140 moulds, or cans, of turned steel, in frames, and produces the quantity of ice before named, each block of ice weighing 1¼ cwt., and measuring 42 inches by 20 inches by 6 inches.

The tank is fitted with a propeller, for circulating the cold brine over the coils and round the ice moulds.

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The ice is made from the ordinary water supplied from the Corporation mains.

Hydraulic agitating gear is also provided for rendering the ice clear to within something like 7 per cent. of the total capacity of the block.

Labour-saving Appliances. — The following labour-saving appliances are provided in connection with the ice tank:—

Fourteen carriages, each holding 10 moulds, made of wrought-iron, with cast-iron ends.

One overhead travelling crane, by means of which a whole row of moulds with their carriages are lifted, discharging the ice; the moulds are then refilled with water, and returned to the tanks by one man at one operation.

A thawing-off tank is also provided at the emptying end of the ice tank, and contains warm water to enable the blocks of ice to be easily detached from the moulds. They are then, by the tipping gear, discharged by means of the crane on to the platform. From this platform the blocks can either be lowered into the cellar or put into carts for delivery.

The filling gear consists of a tank of wrought-iron, in which the ice-making water is contained, enabling the moulds to be filled at one operation, each with the proper quantity of water.

Before describing the insulation of the Stores and the ice cellar, it should be mentioned that offices, together with the necessary lavatories and stores, are also provided.

A special feature about the building is that the roofs of the engine room, tank room and the stores are kept flat, being formed with concrete and steel joists. This is for the purpose of using the same for the condensers, and also for keeping the building as much out of the sun as possible.

The main building of the new Market will keep the Stores, to a large extent, in a shaded position.

Appended to this paper is given the approximate cost of the different sections of this work, and a price list of charges made for storage and ice.

Insulation.—Every effort has been made to obtain a satisfactory insulation for the walls, the floors and the ceilings, as the economical working of the Stores depends largely upon the quality of the insulation. This runs into a considerable sum of money, working out at approximately 2*s.* per cube foot of storage.

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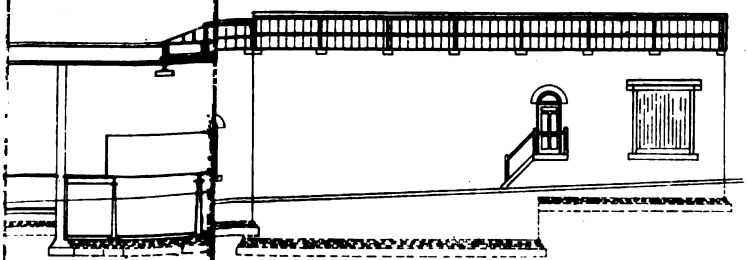
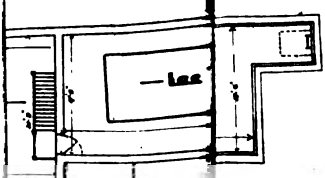
COUMPTON

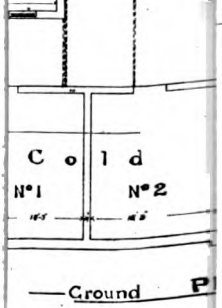
ES

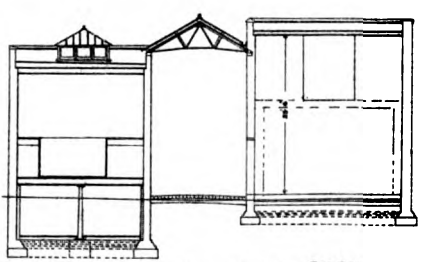
DRAWING Nº 1.



Section Elevation to Ice Factory







Section EF

Geo. Green
Born Engineer
Nov 1901

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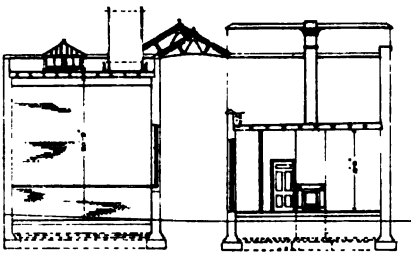
HAMPTON

2 ORES

DRAWING Nº 2

evation to Cold Stores



Ro

Section C.H.

George Green
Board Engineer
Nov. 1904.

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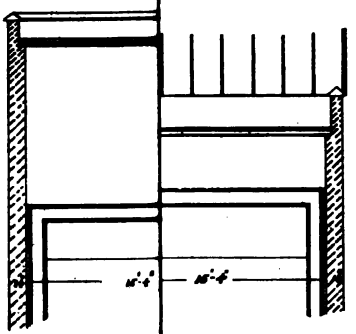
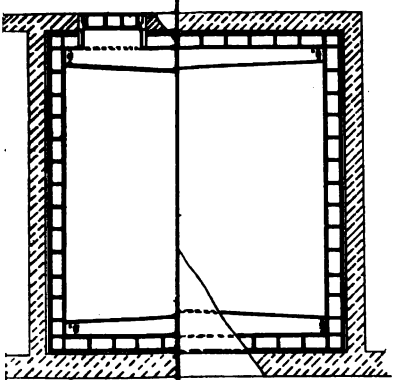
No. 4

COUNAMPTON

IRES

DRAWING No. 3





Coe, Green & Co.
Sure Engineers
Nov 1908

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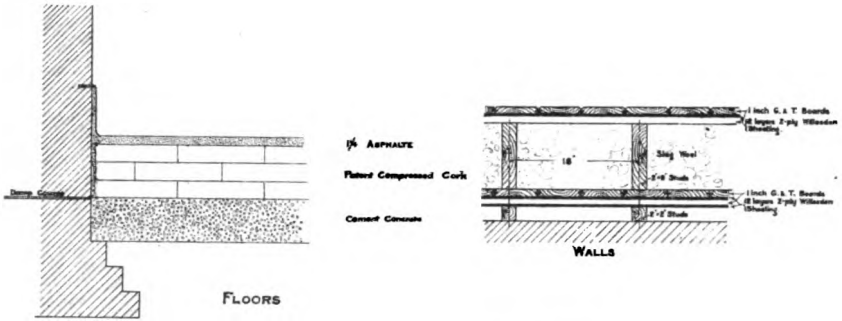
CONTRACT Nº 4.

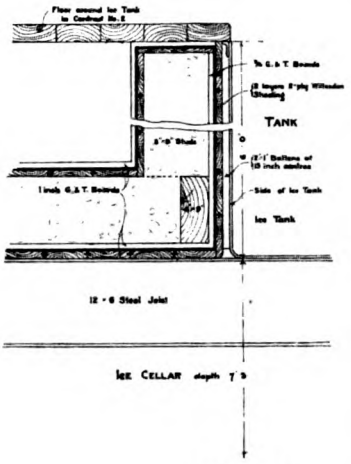
COUNTY BOROUGH OF WOLVERHAMPTON

DRAWING Nº 4.

DETAILS OF INSULATION

COLD STORES




Flow around Ice Tank to Contract No. 5
½ G.& T. Boards
(2 layers 2-ply Willesden Sheathing)
TANK
2"×9" Studs
12 (2'-1" Battens at 10 inch centres
1 Inch G.& T. Boards
Side of Ice Tank
Ice Tank
12"×6 Steel Joist
ICE CELLAR depth 7'9

G. Green A.M.I.C.E.
Borough Engineer.

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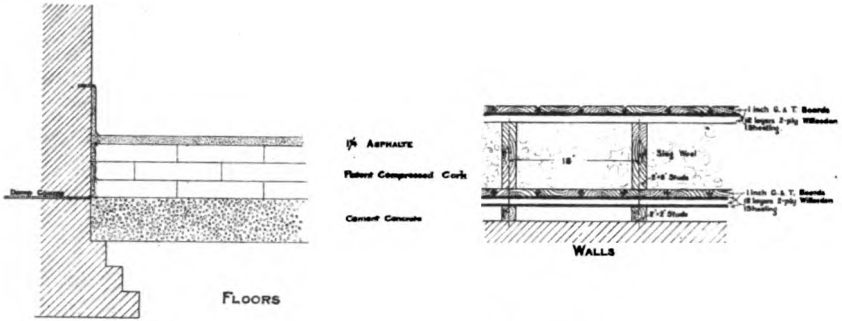
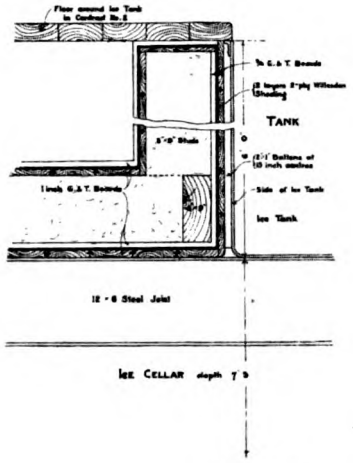
CONTRACT Nº 4. **COUNTY BOROUGH OF WOLVERHAMPTON** DRAWING Nº 4.

DETAILS OF INSULATION

COLD STORES



DOORS


Floor around Ice Tank to Contract No. 5
½ G.& T. Boards
(2 layers 2-ply Willesden Sheathing)
TANK
3"×9" Studs
(2'-1" Battens at 10 inch centres
1 inch G.& T. Boards
Side of Ice Tank
Ice Tank
12" × 6" Steel Joist
ICE CELLAR depth 7'-0"

G. Green A.M.I.C.E.
Borough Engineer.

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The floors of the Stores were, in the first instance, constructed of 6-inch cement concrete, upon which, in case of the ice-cellar, was laid $\frac{3}{4}$ inch of rock asphalt; this was continued up to the damp-course, and joined to that by means of a "hot" seam.

The ordinary method of floor insulation was deviated from in this case, and a new material, which has been in use some little time and which has proved to be of a satisfactory nature, was laid in place of the ordinary flooring of timber and slag wool. This consists of three slabs, laid one above the other, of a patent material, composed of granulated cork and cement compressed together and forming a solid slab or brick. Upon the top of these were placed two layers of rock asphalt $1\frac{1}{4}$ inches thick. This floor has been found an excellent insulator, and at the same time has the advantage of being solid.

It is an improvement on the wooden floor, inasmuch as it can be thoroughly cleansed, and, should any liquids be spilt upon it, no damage can be done to the insulation.

The walls and the ceilings are insulated with timber and slag wool. In the first instance, 2 inch by 2 inch red deal studs, 18 inches centre to centre, are secured to the brick walls with plugs. They are afterwards covered, and the spaces between them, with one layer of "Giant" insulating paper, secured to the studs with tacks and marine glue. Immediately upon this are placed two layers of 1 inch red deal grooved and tongued boarding—the first is laid horizontally and the second vertically —with one layer of similar waterproof paper between. 2 inch by 9 inch red deal uprights at 18 inch centres are then fixed, to which are attached again two layers of 1 inch grooved and tongued boarding, with waterproof paper between, as previously described. The 9 inch space is carefully and firmly filled with slag wool.

The ceiling is treated in a similar manner. Slag wool, of course, being put in from the top before the upper boarding is laid.

In the case of the ice cellar, the walls are covered with asphalt up to the top, and after the insulation has been fixed in a similar manner to that in the stores, the inside walls are then fitted with 2 inch by 1 inch "dunnage" or "cargo" battens at 15 inch centres, to prevent the blocks of ice adhering to the walls, and to admit of a free circulation of air round the materials stored.

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The ceiling of the ice cellar is largely formed by the bottom of the ice tank, and has no means of being kept cool otherwise than by the tank.

The doors are patent ones, supplied by the Insulating Syndicate Co., Ltd., and are provided with the "Wallington" patent fasteners, hinges, etc., complete. Each doorway also has a canvas "Willesden" curtain to prevent unnecessary escape of cold air.

Details of the insulation are supplied with this paper in order to save more lengthy description.

The whole of the inside of the stores is painted in white, and finished in white enamel, so as to make the same as light, clean and sanitary as possible.

A hand lift for the purpose of lowering and raising ice to and from the cellar, is being provided.

The entire building is lighted by electric light.

The Author feels an apology is due to the Association for the incompleteness and shortcomings of this paper; and, while fully aware of the many defects, he must ask the indulgence of the Association, owing to the shortness of time at his disposal to devote to the subject, under the exceptional pressure of work devolving upon his department during the year of the Exhibition.

He is informed that the Corporation never had so many important municipal works in hand as at the present time, and added to these the Exhibition, visits of numerous deputations to inspect the new Surface Contact Tramway System, and the preparations for the Coronation. Little time has therefore been left to do justice to the subject, or to render that consideration to the Association which is its due.

He trusts, however, that this explanation will be magnanimously received.

APPENDIX.

Approximate Cost of Wolverhampton Cold Stores.

	£
Building contract	3315
Plant and machinery	2872
Insulation	1729
Motors	523
Furniture, fittings, etc.	281
Lift	50
Total	£8770

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PRICE LIST FOR STORAGE.

Meat, etc.

	s.	d.
Quarter of Beef, first 24 hours or portion	0	9
„ „ each succeeding 24 hours	0	6
„ „ per week	2	6
Sheep and Lambs, first 24 hours or portion	0	4
„ „ each succeeding 24 hours	0	3
„ „ per week	1	0
Calves and Pigs, first 24 hours or portion	0	8
„ „ each succeeding 24 hours	0	4
„ „ per week	1	6

Meat, Pieces and Packages, 7 days or portion, $\frac{1}{8}$th of 1*d.* per lb.

Any pieces, etc., required from Packages, the latter must be brought from room, paid for, and re-invoiced.

Fish, Game and Poultry.

Poultry, Rabbits, Game, etc. (fresh)	$\frac{1}{8}$th of 1*d.* per lb., 7 days or portion
Rabbits, Frozen, 100 cases and upwards	15*s.* per ton, 28 days or portion
Ditto, less than 100 cases ..	20*s.* „ „
Poultry, Frozen	20*s.* „ „
Ditto, 10 cases and less ..	$\frac{1}{10}$th of 1*d.* per lb., 7 days or portion
Fish, wet	1*s.* per cwt., 7 days or portion
Finnon and Kippers ..	1*d.* and upwards per box, 7 days or portion
Loose Fish	2*d.* each and upwards, 7 days or portion
Salmon, Columbian	$\frac{1}{8}$th of 1*d.* per lb., 28 days or portion

Minimum charge, 6*d.*

Offal.

	d.		
Beast Livers	2	each, 7 days	or portion
„ Plucks	1	„	„
„ Hearts	1	„	„
„ Tongues	1	„	„
„ Heads	1	„	„
„ Tails, per dozen	4	„	„
Sheeps' Heads and Plucks	1	„	„
Calves' Heads	1	„	„
Tripe	$\frac{1}{8}$ of 1*d.* per lb.		„

Minimum charge, 6*d.*

Provisions, etc.

Butter	6*d.* per cwt., 7 days or portion. Large quantities, 17*s.* 6*d.* per ton, first 28 days or portion, and 5*s.* per ton per week after, never to exceed 17*s.* 6*d.* per ton per month. Small quantities, 20*s.* per ton, 28 days or portion
Cheese, Bacon and Lard ..	Large quantities, 10*s.* per ton first 28 days or portion, and 3*s.* per ton per week after, never to exceed 10*s.* per ton per month

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Eggs .. .. Large quantities, 9*d.* per case first 28 days or portion, and 3*d.* per case per week after, never to exceed 9*d.* per case per month

Milk .. .. 9*d.* per can, 7 days or portion; 4*d.* per can, 24 hours or portion

Prices for fruit and goods not previously mentioned and quotations for large consignments may be obtained from the Manager.

Ice Department.

Ice will be sold daily (Sundays excepted) from 7 a.m. to 5 p.m.

Prices (Ex Factory).

									s.	d.
¼ cwt.	..	..	..	..	..	..	..		0	9
½ cwt.	..	..	..	..	..	..	..		1	0
1 cwt. to	4 cwt.	..	..	..	..	..	per cwt.		2	0
5 „	9 „	..	..	..	..	..	„		1	9
10 „	14 „	..	..	..	..	..	„		1	6
15 „	and upwards	..	..	..	..	..	„		1	3

Special prices for large quantities may be had upon application.

Arrangements for delivery of large quantities may be made on application to the Manager.

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WOLVERHAMPTON CORPORATION TRAMWAYS ELECTRICAL EQUIPMENT.

By C. E. C. SHAWFIELD, A.M.I.E.E., M.I.Mech.E.,
Borough Electrical Engineer, Wolverhampton.

In presenting this paper to your notice, the Author would explain that it is the outcome of a request made by the Borough Engineer of Wolverhampton that a short paper should be prepared on the Electrical Equipment of the Wolverhampton Corporation Tramways, and consequently the Author has not attempted to write more than a brief description of some of the principal features in connection therewith; as, in the first place, extreme pressure of municipal work has prevented him from devoting so much time to the subject as he could have wished; and secondly, inasmuch as the system is on its trial, it is of course impossible for the Author to express any opinion as to its merits or demerits.

The Surface Contact System of electric traction was first brought before the Tramways Committee in March 1901, when an offer was made to them by the Lorain Steel Co., of America, to equip about 11 miles of single track with their system, and to allow the Corporation a twelve months' trial thereof on the understanding that if the system failed to prove itself thoroughly safe and reliable, and commercially successful in operation, it should be taken up again and the whole cost of the experiment borne by the company.

After lengthy negotiations a contract was entered into on this basis with the Lorain Steel Co., and accepted by the Council on the Committee's recommendation.

The portion of the tramways upon which this system is being tried consists of about 5½ miles of double track running from the south-east to the north-west corner of the borough, traversing the principal streets in the centre of the town, and

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forming a loop through the residential districts of Tettenhall and Whitmore Reans, as shown on diagram No. 1.

Feeder and Distributing System.

The whole of the feeder and distributing cables were supplied and laid by Callender's Cable and Construction Co., Ltd., on their well-known solid system. Each cable consists of a stranded copper conductor of 100 per cent. conductivity, insulated with vulcanised bitumen, which is protected externally by tape and hemp yarn braiding.

The cables are laid in troughs constructed of seasoned red deal impregnated with preservative compound, and are supported at intervals of 18 inches by wooden bridges. The troughs are filled up solid with Trinidad bitumen, and covered over with hard blue bricks as a protection against mechanical injury.

The main feeder cables are in all cases laid under the footway at a depth of from 14 to 18 inches, the sectional area of the conductor varying from ·2 square inch to ·4 square inch.

The distributing cables (which correspond to the trolley wires of the overhead system) are laid in the centre of each track under the concrete bed of the permanent way, and are divided up into sections not exceeding 100 yards in length, in order to facilitate the ready localisation of faults either in the cable or in the contact boxes. The sectional area of each distributing cable is about ·05 square inch. The feeder pillars are located on the footpath at distances of 200 yards apart, the main feeder being taken into each feeder pillar and connected to a bus bar, from which the current is supplied to the distributing cables under the track by means of four switch fuses.

The feeder pillars are supplied by Callender's Cable and Construction Co., Ltd., and are of the same type as is commonly used in the overhead system. A diagram of the connections between the main feeder and the distributing cables is shown on diagram No. 2.

Each feeder pillar has a distinctive number painted on the outside, and each of the four distributing cables branching therefrom are lettered A, B, C and D respectively. The contact boxes connected to each of these distributing cables are numbered progressively from the feeder pillar to the end of the

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section, the first box being No. 1, so that by this means any box on the system can be instantly located by giving its feeder pillar number, distinctive letter, and progressive number.

Telephone System.

A 3-core pilot and telephone cable is laid in the same trough with the main feeder cables, and a tapping is taken therefrom into every feeder pillar and joined through a disconnecting board to a telephone plug placed on the door of the pillar. These telephone cables are all connected to a small exchange at the generating station.

A telephone instrument is carried on each car, so that in the event of a breakdown on any line the driver or conductor of any car has only to go to the nearest feeder pillar, which cannot be more than 100 yards distant, and can at once communicate either with the chief engineer's office, the switchboard at the generating station, or with the traffic manager's office at the car shed. Means are also provided by which any one feeder pillar can be put in direct telephonic communication with any other feeder pillar on the system. The whole of the telephone apparatus, with the exception of the 3-core cables, were supplied by the General Electric Co.

Bonding.

Each rail joint is bonded by three 000000 S.W.G. copper bonds fixed on the inner side of each rail, the holes being punched through the web of the rail and reamered out the correct size at the time of fixing the bonds. Two Columbia bonds and one Neptune bond are used at each joint, the area of contact at each bond being approximately seven times the cross section of the bond. Cross bonds are also inserted at distances of 120 feet, and the up and down tracks are bonded together at similar intervals. In each case where any special track work occurs, the joints between the rails and the special work, and between the various sections of the special work, are bonded together as described above, and in addition the whole length of special work is bridged over by heavy copper stranded cable. Provision has also been made at certain points for the connection of return feeder cables to the rails, should they be required at any future time.

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Two insulated cables are connected to the rails at a point in Bilston Road, and form the return feeders from the rails to the negative bus bar at the works. The combined cross sectional area of these cables is equivalent to one square inch.

Contact Boxes.

The following description of the construction and method of fixing the Lorain Contact Boxes is taken from a report made on the system in March last by Mr. Henry Lea, M.Inst.C.E., Consulting Engineer, Birmingham, who was called in by the Council to report on the system, and to whom the Author is also indebted for the lettered drawing shown on diagram No. 3:—

"A is the trough containing the cables B B^1, which are provided and fixed by the Callender Cable and Construction Co., Ltd. Cable B comes from the next contact box on the left of the drawing, and the cable B^1 goes to the next contact box on the right. C is what is called 'the Y casting,' which rests upon the cable trough A, and contains the ends of the cables B and B^1. This Y casting is filled with Callender bitumen up to the level Y^1. D is the 'Bell casting,' which has a ring nut D^1 by which it is secured to the 'reconstructed granite block' E. The word 'reconstructed' means that the block is made of granite which has been reduced to powder by the action of the atmosphere, and, after having been mixed with other ingredients, has been subjected to very great pressure in a suitable mould, whereby it is accurately formed into the desired shape. The granite block E rests upon the concrete F, each block being carefully adjusted by means of a gauge to a definite height in relation to the surface of the tramway rails. After the granite block, together with the Bell casting D, has been placed in position, the space round the upturned ends of the cables B B^1 is filled up to the line D^2, with what is called the box compound poured in hot. Next the 'cable terminal insulator' G is placed within the Bell casting D. This insulator contains the 'brass cable terminal' H, which has two holes in it through which the copper conductors of the cables pass vertically, the said copper conductors being then sweated into the said cable terminal, so as to form a sound electrical connection. More box compound is then poured in through holes in the flat bottom on the insulator G, whereby the cavity above the level D^2 is completely filled up with box

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compound, which rises until it has filled the holes through which it was poured, as aforesaid. The brass terminal H has a sort of blade or tongue I projecting vertically upwards within the insulator G.

"The 'hollow armature cup' K K^1 is made of special insulating material, and consists of an upper portion, K^1, and a lower portion, K, which might, perhaps, be called the 'cover' and 'base' of the cup respectively. The bottom terminal L, is embedded into the material of the base K, and to its underside are attached the two spring clips M M, while to its upper side is attached the copper conducting-ribbon N, the latter being folded upon itself four times, so as to form an extremely elastic connection between the bottom terminal L and the bottom carbon O, just below which the soft iron armature P intervenes. The cup cover K^1 has embedded in its substance the top terminal L^1, to the under side of which is attached the top carbon O^1, leaving a space of about $\frac{3}{4}$ inch between the bottom carbon and the top carbon when the armature is resting on the cup base K. The upper side of the top terminal L^1 is provided with a screw nose L^2, which is screwed into the central portion of the street contact plate, which consists of a special non-magnetic steel centre piece Q, having cast upon it the two cast-iron side pieces Q^1, the said three pieces, Q, Q^1, forming what is hereinafter referred to as the 'contact plate.' Reverting for a moment to the armature cup K K^1, it may be mentioned that the upper and lower portions of this cup are clamped together by means of a screw ring and nut K^2. It will thus be seen that the assembled parts K to Q, attached to each other as described, can be lifted up as one piece, and lowered into the recess in the granite block E; and that when so lowered the spring clips M will grip the tongue I, whereby the copper conductors of the cables B, B^1, will be put into electrical connection with the bottom carbon O; and when the bottom carbon O has been raised so as to touch the top carbon O^1, the said cable conductors will be in electrical connection with the contact plate Q. R R are two holding-down bolts, which are cemented into the granite block E, so that their upper ends are about level with the top of the said granite block. Before the contact plate with its accessories is lowered into the recess in the granite block, the said recess is partially filled with a special material called 'dope,' which is poured in in a hot

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melted state, and in that state is sufficiently fluid to rise and fill all the spaces between the granite block E, the armature cup K K^1, and the contact plate, as the latter is lowered into the granite block. S is a flat washer or gasket, the thickness of which is adjusted to ensure the top of the contact plate standing at the required height above the rail level."

This completes the description of those portions of the system which are fixed in the roadway. The other parts shown on the drawing are those which are attached to the under side of the car truck, and which, therefore, travel with the car. T T are the two magnet skates which are carried from the yoke T^2, and are excited by the magnet coils T^1, of which there are twelve connected up in series, and arranged as a shunt across the 500-volt supply terminals. The resistance of the twelve coils is 460 ohms, and they carry, therefore, at 500 volts, a current of 1·09 amperes. The coils are also wound with a larger wire, in series with the motors. This wire carries the current passing through the motors, whereby the more current the motors are using, the more intensely the magnet skates are magnetised, and the more forcibly the carbon contacts are held together. The magnet skates are each about 17 feet long, but are not continuous magnetically, each being cut into six separate lengths, and each separate length being magnetised by one of the twelve coils T^1. For structural continuity the six lengths are united end to end by gun-metal connections, so as to form one skate 17 feet long, as aforesaid. The yokes T^2 are carried from portions of the truck frame, which are connected directly to the axle boxes, whereby the action of the springs of the vehicle does not affect the height of the magnetic skates above the contact plates. The magnetic skates do not touch the street contact plates. U is the collecting skate, which does touch the contact plates and receives from them the energy which drives the car. In order that the collecting skate U shall have an elastic pressure on the contact plates, it is secured to the under side of a stout rubber tube V, by means of the screws U^1. W is a longitudinal bar of wood, which is secured to the yokes T^2 by means of bolts X. The bar W carries the rubber tube V by means of the bolts W^1. A drawing of the complete magnet equipment and collecting skate is shown on diagram No. 4.

The method of operation of the contact block may be briefly

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described as follows. So long as there is no car immediately over the box the soft iron armature P, together with the lower carbon contact O, remain at rest on the bottom of the armature cup K K¹, and the street contact plate remains "dead." Immediately, however, upon the passage of the car over the box the magnetic lines of force from the magnetic skates T T are projected downwards through the cast-iron cheeks, Q¹ Q¹, of the street contact plate, and complete their circuit through the soft iron armature P, which is immediately pulled up until the lower carbon O makes contact with the upper carbon O¹, thus making the street contact plate "alive," and transmitting electrical energy from it to the collecting skate U, and thence to the motor equipment of the car.

As soon as the car has passed, however, carrying with it the magnetic skates T, the magnetic attraction ceases, and the soft iron armature P, together with the lower carbon contact O, drop back to their normal position at the bottom of the hollow armature cup K K¹, cutting off the supply of electrical energy and leaving the street contact plate dead.

As the contact boxes are set 10 feet apart in straight track, and closer together on curves, and as the collecting skate is 13 feet in length, it is obvious that the skate is always in contact with one or more boxes at a time, and, consequently, the supply of energy to the car is continuous.

It will be seen from diagram No. 4 that the magnetic skates project about 2 feet beyond either end of the collecting skate. The effect of this is, that each stud is made "alive" before the collecting skate reaches it, and is kept "alive" until after the collecting skate has left it. The object of this arrangement is to ensure that there shall be no sparking between the carbon contacts O and O¹, due to the making and breaking of the driving current of the car.

The Author hopes to be able to arrange for a sample contact box to be fitted up and operated for the inspection of the Association, in order to illustrate the foregoing description.

Rolling Stock.

The cars in use at the present time consist of three types, viz. double deck, single deck, and single deck combination type, all of which are mounted on Du Pont and Brill single trucks.

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In order to facilitate the attachment of the magnetic equipments, the trucks have been made with 6 feet 6 inch wheel base and 33 inch wheels instead of the usual 6 feet wheel base with 30 inch wheels.

The general dimensions of the cars are as follows:—

Double Deck Cars.

	ft.	in.
Overall length	27	6
Overall width	6	4
Overall height from rail	13	2

Seating capacity, 22 inside, 26 outside.

Single Deck Cars.

	ft.	in.
Overall length	26	0
Overall width	6	0
Clear height inside	7	8½

Seating capacity, 26 inside.

Single Deck Combination Cars.

	ft.	in.
Overall length	26	0
Overall width	6	0
Clear height inside	7	8½

Seating capacity, 16 inside, 10 outside.

All cars are fitted with twin doors opening in the centre, and the double deck cars are fitted with reversed stairway of the Liverpool type. All cars are provided with route indicators at either end, which are illuminated at night.

The motor equipments of these cars have been supplied by four different firms, viz. Lorain Steel Co., British Westinghouse Co., British Thomson-Houston Co., and Dick, Kerr and Co., and consist in each case of two 25-horse-power motors with single reduction gear, with ratio of 4·8 to 1. The controllers are of the series parallel type, and in addition to the usual operating notches, are provided with five electric brake notches, in order that the motors may be used for braking purposes in case of failure of the ordinary mechanical brakes.

The life-guards or fenders are of the type patented by Messrs. Wilson and Bennett, and consist of two principal parts, one, the guard proper, which is carried from the truck under the platform, and is raised under normal conditions about three or four inches clear of the rails. The other portion is the hanging-

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MUNICIPAL TRAMWAYS

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DIAGRAM No 1.

HALL

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CABLES

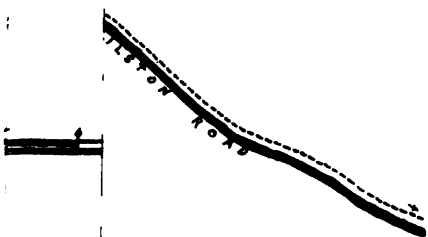

PHOTO-LITHO. SPRAGUE & Co LTD 4 & 5. EAST HARDING STREET, FETTER LANE. E.C.

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DIAGRAM Nº 2.

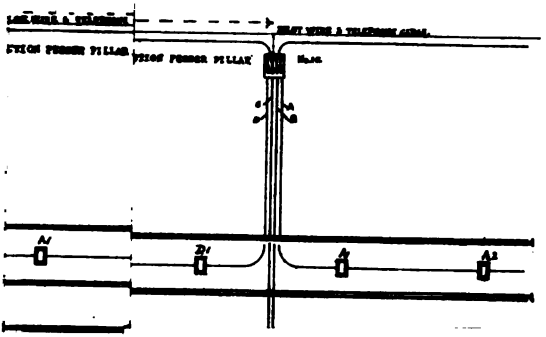

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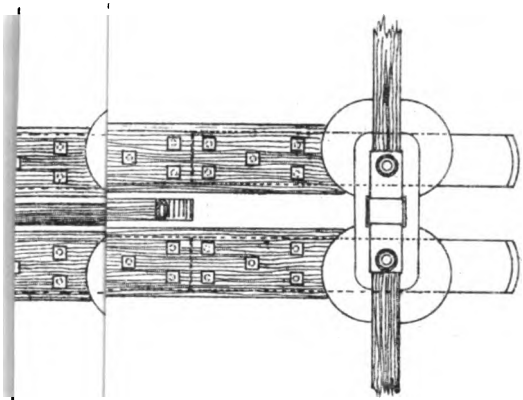
DIAGRAM Nº 4.



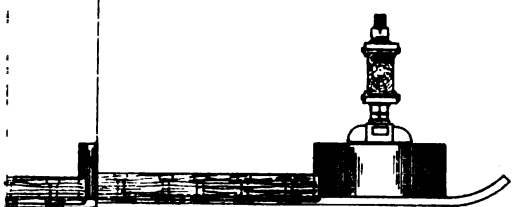


PHOTO-LITHO. SPRAGUE & Cº LTD 4 & 5. EAST HARDING STREET, FETTER LANE. E.C.

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gate, which is suspended from the platform of the car at either end, and on coming in contact with anything lying on the track, is pushed back, and forces the guard behind it close down upon the surface of the roadway, the obstructing body being picked up on the guard, and prevented from getting under the wheels.

In conclusion, the Author would say, that whilst he has endeavoured to describe and explain the major points of interest in connection with the Electrical Equipment of the Wolverhampton Tramways, there may be several details upon which further information may be desired; and he will be most pleased to give any Member of the Association any particulars that may be required.

DISCUSSION.

Mr. J. PRICE: I have much pleasure in proposing a hearty vote of thanks to the Authors of these papers. I think every one will agree that they have made this meeting a success by the contribution of these carefully written papers. I think one cannot help admiring—I was going to say the audacity—the pluck Mr. Green has referred to in the carrying out of an entirely new system of electrical traction. As one who has carefully considered the matter, I cannot help being struck with the fact that such a system as this, if successful, would overcome very many of the difficulties which we have in the overhead and conduit systems. But this system has its own defects. These, I suppose, we shall be able to see at a later period to-day when we examine the lines. The estimated cost of the tramways is put down at 210,000*l.*, which works out at 9000*l.* per mile. I should like to ask what was the estimate per mile of the overhead system, or the total, as that will show at once what is the difference in the capital outlay upon the two systems. The construction of the joint in the tram rails is practically the same as has been adopted in Birmingham. I should like Mr. Green's candid opinion upon it. I should like to know whether in the narrow streets these 60-feet rail lengths are found awkward in handling; whether there is any difficulty in getting such a long rail thoroughly bedded, because the wear and tear of that rail will depend absolutely upon that point. As to the street boxes, the objection raised is that if you have

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very heavy loads passing down the streets, these weights bearing upon the boxes will be liable to cause dislocation in some parts of the structures, and then you will have the penetration of moisture into the internal portion, and then trouble. I see Mr. Green has had to lay some of his work in the winter—or attempt to lay it. I advised my committee, in a similar case, not to press the point, and eventually we gave it up. It is one of the most difficult things to construct a thoroughly sound and substantial tramway even under the best circumstances, and it certainly ought not to be tackled in wintry weather.

Mr. J. T. EAYRS: I have been asked to second this vote of thanks, and I do so with very great pleasure. I can quite appreciate the difficulties of the Authors of these papers, both the Borough Engineer and the Electrical Engineer, in preparing them for our consideration this morning. This Lorain contact system, which is entirely new in this country, has only been laid down here practically as an experiment; although it is an experiment of a very large and important character. It is such an one as engineers like to see, because you can examine the line in its entirety, rather than a length of 100 or 150 yards, which is usually done to show you the merits of a system. Here we have it put on a commercial scale, such as every one can appreciate. It would be difficult for Mr. Green or Mr. Shawfield to speak on the merits of the system, because, as I understand, the company that have laid it down have done so under some guarantee that if it does not answer it is to come up again; and it is quite natural that the engineer would not commit himself until it has had a full and fair trial. There are one or two points which strike me in regard to Mr. Green's paper. On page 186, on the question of paving, he says, "In one case chilled steel blocks have been laid alternately with the courses of setts in order to prevent ruts being worn (against the tram rails) in the sandstone setts." I should like to know whether these chilled steel blocks have been down sufficiently long, and whether he can form an opinion as to their suitability for the purpose. I remember some years ago similar blocks were laid down in the north of London alongside a tram track. I found they did not prevent rutting; they were exceedingly objectionable to drive over, and were not at all satisfactory. I should think they will not be satisfactory, as the difference in wear between the chilled steel block and the sandstone sett will be so

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great. Then with regard to the prismatic blocks and their expansion and contraction. I had an opportunity some time ago of observing these blocks. They are simply blocks formed of wooden pegs about 1 inch square and bound round with light hoop iron to keep them together, and then, I believe, dipped in some bituminous compound. My own observation of them at Worcester, where they were laid extensively, was that they wore very badly and very unevenly after they had been down some time; and when taken up for repair all the hoop iron had rusted and the blocks were all to pieces. It is worth your while to inspect them, because it is a pavement one does not see every day. I must say I cannot appreciate its advantages. The next point I would like to call attention to is on page 186, where Mr. Green says, "There are no doubt many persons who do and will object both to the appearance and projection of these boxes in the paving. Those who do not mind the appearance must admit that they cause some slight jarring when driving over them." I have heard that there are residents in Wolverhampton who say that in driving, when they can avoid this tram track they do so, and I do not think that cyclists can appreciate riding over these contact boxes. Mr. Green says, "It would be advisable to protect the edges of the boxes from traffic." It appears from that that Mr. Green has some doubt in his own mind as to the durability of these boxes. I should say if you get heavy traffic passing over them, such as is common in south Staffordshire, with loads going up to 30 tons in weight, it might crack some of these "reconstructed granite" cases, and cause moisture to get in the boxes; and as soon as the insulation is gone there is an end to your system. With regard to the electrical connection, it strikes me, in comparing this with the overhead trolley, there is a greater danger of leakage. In the trolley system the connections are somewhere about 40 yards apart, whereas in this system there is a connection every 10 yards, and each connection means a danger of leakage from defects in the work or in other ways. No mention has been made of the wear and tear. It strikes me there will be a tremendous amount of wear and tear on the skates running underneath the cars. These skates, with the constant rubbing every ten yards, and on the curves at much shorter distances, will wear out rapidly. I should like Mr. Green to tell us whether there has been any such wear and tear of an excessive character. Also I should like him to say

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how long the line has been in operation; the number of car miles which have been run over the system; and also the cost of working per car mile.

The PRESIDENT: There is one point I should be glad for you to deal with in the discussion, and that is as to one particular expression of opinion as to the foreign work relating to the special track work—e.g. that that work has advantages over the English work. That is a matter of importance just now in putting down tramways. I should like to mention one other thing, and that is, that Mr. Green in his paper gives credit for the work done by his predecessor.

Mr. EAYRS: Can he give us more details as to its make, and whether it can be made in England, or whether we shall have to go to America?

Mr. HOWARD-SMITH: We are exceedingly indebted to the Authors of these two papers, so full of interesting description and practical details of a system of electric traction, which, on a commercial scale, is quite novel, though, from what we can see of its smoothness of working and completeness of detail, it would certainly warrant the view that it has come to stay, and we trust it will prove, both mechanically and commercially, successful in Wolverhampton. Experience of the practical working of the Lorain surface contact system, under everyday conditions, being so recent, it is hardly possible to offer effective criticism of the special mechanical and electrical details, with regard to which, I take it, most of us are here to obtain information rather than to give criticism. An undesirable detail however, that I noted, is the necessity to have the contact boxes at very short intervals where the track is laid to a sharp curve. One can imagine that at a busy corner in the centre of a large town—a place where sharp curves usually occur—this might prove a very grave objection. It is stated that the contact boxes are so fixed that the apex, or rubbing piece, shall be "at a certain distance above the rails"; perhaps this distance could be given, as this is a detail of much importance. I understand the "artificially reconstructed granite" is a recent production and has not yet stood the test of time. I suppose there is no fear of its disintegration after a few years' wear—a not unusual experience with some kinds of artificial stone when subject to vibration. I have some experience of the exceptional traffic on the roads in this district and the damage sometimes caused. I

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recall an incident which occurred under my own observation. A traction engine, while hauling a large boiler, skidded on the tramway rails and the cross-bars on the revolving wheels ground out the surface of the rails to a depth of about an eighth of an inch. It occurred to me that the results might be serious if a traction engine were to skid in a similar manner on a contact box. It would I think be of value if Mr. Green would add particulars of the chemical and mechanical tests which were applied to the rails—the question of such tests is one of much importance.

Will Mr. Green say if any and what practical difficulties were experienced with the 60-feet rails he used. Upon the question of the respective qualities of English and American point crossings and "special work," I quite agree that those of American make are very good, though somewhat costly, and the methods of American makers are usually both practical and scientific. There are, however, English makers who adopt similar methods, by which alone can success be ensured, and their work leaves nothing to be desired, though with others, there is rather too much tendency to keep to old patterns and methods rendered obsolete since the introduction of electric traction. No little experience and mathematical skill is requisite to properly design "special work" with the several crossing angles, points of intersection, deflection angles, leads, spiralising of curves and other details. Too often this is left to rule of thumb or handed over to makers to work out their own data, which can hardly be regarded as altogether desirable or in all cases likely to lead to satisfactory results. One objection to using what I may term shop-patterns is, that they are usually designed for laying in a flat street without any regard to cross-fall or other circumstances of locality, and with points and crossings my experience is that sufficient regard is not always paid to scientific requirements; for instance, much easier running and longer life would often be ensured by the adoption of a more suitable crossing angle or length of lead—in this respect very much depends upon proper design and efficient platelaying. Perhaps Mr. Shawfield will kindly tell us the special reasons for the adoption of triple bonding at the rail joints, sometimes simple bonding is used, but generally it is double. I quite recognise—where there is a possibility of the mechanical joint not maintaining rigidity, or where it affords no

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medium for the passage of the current—the wisdom of taking extra precautions in view of the possibility of the bond pins working loose. The cross bonding too, I note, is at more than usually frequent intervals. I think, rather than making a fixed distance apart the governing rule for placing these, it is preferable to make this the number of intervening rail joints. Mr. Price remarked that the form of rail joint as used here had also been tried at Birmingham, was this, may I ask, for electric traction? (Mr. PRICE: Yes.) No doubt this will have been quite recently, and only as an experiment, so I suppose an opinion based upon experience, as to its value, can hardly yet be given. (Mr. PRICE: No.)

Mr. J. P. WILKINSON: I wish to express my thanks to the writers of the papers for the concise way in which they have laid before us the details of this novel and interesting system of traction. I think it has already been asked that we may have some further details about the capital cost, because it appears to be 210,000*l.* for 11½ miles of track, which makes it something like 18,000*l.* per mile for double track. The paper does not say whether this sum includes generating plant, cars and accessories, or whether it is the track itself and its electrical equipment. Taking Mr. Shawfield's paper, although the President has asked us to criticise the papers, I think criticism revolves itself especially into a matter of asking questions because we have no experience to go upon in this new system. I should like to ask whether there have been any instances of percolation into the surface contact boxes, and if so, to what extent and what the result has been? Also whether such a small amount of creepage, or internal sweating owing to change of temperature, is sufficient to give any shock either to a horse or human being. There is another point and that is, the liability or possibility of the contact skate being fixed so close to the surface of the ground when passing over the points making contact with the cross-rails, and thus producing a dead short circuit between the contact surface and the cross-over rails. Then in regard to the fore-and-aft rock on the car, it seems to me it may produce sparking between the skate and the contacts. I should also like to inquire if there have been any accidents through live contacts? If there is any system in vogue whereby live contacts are indicated, and any method of ascertaining whether these contacts are in actual and thorough working condition? They

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are innocent looking objects, but if left alive I am sure they would be very dangerous indeed. I should like to ask the cost of working per car mile, as perhaps the cars have been running a sufficiently long time to ascertain this.

Mr. H. T. WAKELAM: I have great diffidence in rising to pass my criticism upon the Wolverhampton scheme of tramways, which is an experimental one, and, as has been said, until we have had something like a twelve months' experiment and a winter trial of the scheme, it is too early in the day to pass any stringent remarks with regard to it. All our thanks are due to the Corporation for giving us the benefit of their experience, and at the end of twelve months we shall be able to thank them more, and see whether the scheme has been a success or not. I hope it will turn out to be a success, as Wolverhampton has ventured upon this project in a manner deserving our very best wishes.

Mr. G. GREEN: I very much appreciate the vote of thanks which you have passed to Mr. Shawfield and myself for writing these papers. The thanks are specially due to Mr. Shawfield, who is not a member of the Association. He has been at great pains in preparing his paper, and the Association should be particularly obliged to him for coming forward and reading to us what you will all admit is the most interesting paper of the day. With regard to the questions put to me, I will try and answer them as briefly as I can. Mr. Price asked the cost per mile for this system against the overhead. Well, the cost per mile which is given in this paper, or rather the total cost given, was really an estimated cost for the overhead, and practically these figures are taken as though it were an overhead line. The 210,000*l.* includes the car shed and also certain street improvements, and therefore it is not fair to divide that 210,000*l.* by the 23½ miles. The street improvements are in many cases extensive, and would run into a very large sum of money. The actual length of the line laid at present is just between 11 and 12 miles. This is the length which is equipped with the Lorain surface contact system. The whole tramway system contemplated covers 23½ miles. The actual cost of the track work executed works out at something like 5500*l.* per mile, single track; this includes the breaking up of the macadam. Up to a short time ago nearly all the roads were macadamised, therefore

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each had to be broken up and concrete laid before the rails could be laid. This does not include the electrical equipment or the Lorain boxes and cables. As to my opinion of the "Victor" joint, as I explained in my paper the contracts were let and the works commenced when I came here; therefore I do not wish to criticise the scheme or design, but I do not like the "Victor" joint as well as some others. It has bolts pulling in two directions through the flange and through the "web" of the rails, and there seems a liability of the bolts pulling in opposite directions, and therefore of the joint becoming loose. With regard to the 60-feet rails, we have had no trouble in Wolverhampton with them, either in carting them through the streets, in curving them to the necessary curves, or bending them to the gradients. I can understand that where there are many narrow streets it would be very difficult, but we have had no difficulty here. I have not found them to be anything but solid on the concrete. In some cases we have found that the concrete under the flange has sunk, and then we have put in liquid cement to fill up the space; but in the majority of cases there has been very little difficulty. Mr. Price also asks whether any of the boxes interfere in any way with the traffic. As far as I know they do not. There is no difficulty in driving over them, and as far as I know we have had no complaints that they have been dangerous to the traffic. Neither have we found any of the boxes damaged by traffic. Mr. Eayrs raised this same point and also Mr. Howard-Smith; but I should like to say we had one case where a heavy weight was passing over the track at right angles. This was a case of an engine drawing two trucks with a very heavy boiler, and weighing between 25 and 30 tons. We had exactly the same experience. One of the wheels was spinning round, and could not move for some time, and this concentrated the weight on the top of one of the boxes. We went to examine the box, and were quite prepared to find it had sunk or something had happened to it, but nothing had gone wrong with it. This occurred about Christmas, I believe, and the box is still in its place and nothing has been done to it. With regard to the chilled steel blocks, I do not think we have had sufficient experience to say whether they are suitable or not, and I really cannot say whether they will be successful. The object is partly to protect the sandstone setts and to keep the paving from wearing in grooves, and at the same time give

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the horses a certain amount of foothold. Mr. Eayrs asked why the boxes projected so much, and whether they had been improperly laid. All the boxes are laid exactly to gauge, both with regard to level and position, and if some appear to project more than others it is not because they have been badly laid. I think they have been laid as accurately as it is possible to lay them. Why they appear to project in some places more than others is probably because of the difference between wood and granite paving. With regard to the "reconstructed granite," this is believed to be the hardest material of this character to be obtained in America. Some of the cases are extremely hard, and although they have been down some months they have not shown any signs of wearing out. Others have had to be replaced after a few weeks' wear. It is the same kind of experience you get with stoneware pipes. You will have some that will last for ever, while others crumble away. I hope a material will be found in England out of which to construct cases harder than these of "reconstructed granite." The physical test for the rails is as follows: "A piece of rail 5 feet long, placed head upwards on cast-iron supports three feet apart, shall resist a blow from a weight of 1 ton falling on centre from a height of 18 feet without causing more than 3 inches deflection or less than 1¼ inch, and the rail shall not show any sign of fracture. The chemical test is: Subject to other provisions of the specification, the steel shall conform to the following analysis—carbon, between ·45 and ·55 per cent.; manganese, between ·8 and ·1 per cent.; silicon, not to exceed ·1 per cent.; sulphur, not to exceed ·070 per cent.; phosphorus, not to exceed ·065 per cent." With regard to the special work made in England, I felt very great diffidence in criticising this, and I put as little in my paper as possible. I feel I have a responsibility in putting forward what one has found in experience with regard to work of this kind. Much of the English work is made in what appears to be a slovenly manner. The crossings and points seem to be made on straight lines; they may be only 5 feet or so in length, but are pretty nearly always straight, though made for a curved track. In the American work you find all the points and crossings are made to the curve of the line in which they are placed, and consequently the wear and tear and the comfort of riding over them makes all the difference in the world; and there is no reason why English firms should

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not make a great improvement by following the American custom. I think I have answered Mr. Wilkinson's question as to cost. There is one other point, and that is with regard to the prismatic blocks. I stated in my paper that these blocks were actually supplied before I came here, and my only remarks were these: that as far as expansion and contraction are concerned there had been no trouble, and it is a very important point. Small wedges of sheet iron are placed at different places to hold the pieces of the blocks together, and I am not sure whether the iron will eventually rust away and the blocks come to pieces. I hope not, because this paving gives a good foothold, and, being sound oak, creosoted, should last many years.

Mr. SHAWFIELD: I should like first to express my sincere appreciation of the kind vote of thanks which you have accorded to Mr. Green and myself. It is a very great pleasure to me to present this short paper to you for discussion, as at the present time when I have to watch on behalf of the Corporation one of the largest experiments in surface contact that has ever been made, I fully appreciate the advantage of hearing the opinions of so many practical engineers from various parts of the country, and I can only wish the discussion on this paper had been of a rather more hostile character. I think the first question raised was with regard to the bonding. Mr. Howard-Smith remarked that the bonding seemed to be rather heavy. Well, in the original specification for the line there were only two bonds specified for each joint, but after certain progress had been made I decided to put on a third bond to every joint, because, although two bonds are sufficient as long as they keep in good order, yet, if they are loosened by vibration, corrosion, access of moisture, or other causes, the conductivity of the joint is greatly diminished. By fixing a third bond it is practically certain that the resistance of the joint will remain fairly low during the life of the rail. As regards the cross-bonding; that was originally specified by Mr. Bradley, the engineer for Westminster, and although it is more frequent than the usual practice, I think the small extra cost involved is money well spent. Mr. Howard-Smith also asked as to the exact height of the boxes above the rails. This dimension is $1\frac{3}{8}$ inch. The spacing of the boxes on the curves varies from the maximum of 10 feet to a minimum of 3 feet 6 inches. As regards the life of the granite boxes, I am afraid I cannot give you any accurate

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information at present. Probably at the end of twelve months I may be able to form some idea, but at present the wear is uneven, and it may be that some of the boxes will wear out and require renewal before the end of the year, while others will be absolutely unaffected. Mr. Wilkinson asked whether water had percolated through into the cups. In several cases water has found its way into the interior in the case of fractured cups. This fracturing was caused when the cups and top plates were screwed together before the boxes were brought into the street. It is sometimes necessary to use a little force in order to screw the cups in. The man engaged to do that work was of the navvy type and used, I think, a two-foot spanner and put all his weight behind it, with the result that many of the cups were badly cracked. It was not found at the time of fixing that this damage had been done, and the result was that the water found its way into the cups, and the leakage over the film of moisture thus caused was sufficient to render the top plates alive at from 300 to 500 volts. In all cases where horses have stepped on these boxes they have either stumbled and recovered themselves or they have gone down and got up again without suffering any permanent ill effects. Pedestrians, too, have stepped on them, but beyond being rather surprised, have been none the worse for their experience. I think the danger from a pedestrian's point of view is rather exaggerated. I have frequently stepped on live boxes and been unable to feel anything, except on one occasion when I had thin boots on and had been walking about all day in the wet; then I certainly did receive a shock, but nothing very serious. With regard to the skates, when the line first opened, the life of the skates was extremely short, being only about 400 car miles. The granite paving between the rails had been rather badly laid, and was in many cases higher than the contact plates, with the result that the skates were very soon worn away. But since then improvements have been made both in the skates and the paving, and the average life of a skate now is well over a thousand car miles, and I think it is increasing as time goes on. I think the life of the skates, where the pavement is in decent condition, ought to be at least three thousand car miles. The rocking of the car does not cause sparking, and does not affect the question of contact between the skates and the boxes, because the skates are carried from a frame which rests directly on the car axles and is not affected

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by the compression of the springs. The cost per car mile of operation I am afraid I cannot attempt to give you. It is only really since the first of May that the line has been running on anything like a large scale. The total car mileage run up to the present time is about 30,000, but I cannot give you any idea of what the cost has been, and I do not think it would be possible to give that figure even approximately on less than six months' experience. There was one point raised with regard to the width of the car. The track gauge is 3 feet 6 inches, and the cars were designed to such a width as would admit of comfortable room for passengers both inside and outside, and at the same time would allow of the tracks being constructed with a minimum clearway distance between them. The testing of the boxes is done by men who go up and down the line with low reading voltmeters, and it has been continued chiefly because there has been this trouble with broken cups. There is also a safety skate fitted to the rear of some of the cars, which touches the top of each box as the car leaves it, so that if it touches a live box it rings an electric bell on the platform of the car and lets the conductor know what has occurred.

Mr. EAYRS: Will you tell us the cost of the electrical equipment?

Mr. SHAWFIELD: As regards the cost of the electrical equipment, the cost of cables under the track, the boxes, and the feeder pillars at the side of the road, is 1800*l.* per mile of single track. This is, roughly, 500*l.* per mile more than the overhead system.

Mr. EAYRS: That does not include the feeder cables?

Mr. SHAWFIELD: No.

Mr. JONES: I do not see any metallic contact from the skate to the motor. It is only shown by a rubber ring.

Mr. SHAWFIELD: There is a cable bolted to one end of the collecting skate, and carried from there to the controller. In reply to Mr. Wilkinson as to short circuits, these have been very frequent. They have been caused by scrap-iron, picked up by the magnets, coming into contact with the collecting skates and the cross-rails at terminals and junctions. When the cars first started running, the enterprising youths of the town used to collect scrap-iron or hairpins and scatter them over the boxes and rails, especially at night time, and I have had as many as 80 short circuits in one day. Now I think they are getting rather

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tired of it, and certain improvements have been made so that the number of short circuits has very much decreased.

The PRESIDENT: I cannot let this opportunity pass without very highly congratulating the Authors of the papers upon the intelligent way in which they have, under great difficulties, replied to the questions asked.

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FERGUSSON'S SURVEYING CIRCLE AND PERCENTAGE UNIT OF ANGULAR MEASUREMENT.

By JOHN C. FERGUSSON, M. Inst. C.E.

Ten years ago, the Author had to make a rapid survey with levels of many miles in a very mountainous part of Cariboo, in British Columbia, for the purpose of an hydraulic gold venture on a large scale. He used a special transit-theodolite with stadia wires, and he had tables for the reduction of the reading of the rod for inclined sights; but in spite of the tables, he could not reduce the instrumental work the same night in camp, and if he remained in camp the next day the whole party was delayed. There was no chance of going over the ground a second time, as it was the end of the season and the snow was expected to fall every day. As the water had to be brought about twelve miles there was no margin for error in the levels.

From that time the Author spent all his spare time and used every effort to discover an easier method of reading and measuring angles. He was aware that Descartes and others had attempted the solution of a centesimal division of the circle: that they had worked with the quadrant, also that they had divided the quadrant into one hundred equal spaces, called grades. This system, although it had some practical advantages, still required a new set of mathematical tables as complicated as the old ones used with the degree—the common unit of angular measurement. But all these tables merely express a complicated and ever-changing ratio between the functions of an angle and its radius only. These tables were computed by mathematicians to work with the empirical subdivisions of the circle into 360 degrees or 400 grades.

Now surveyors and engineers have to define the position of objects with regard to other objects and lines, and they have

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to measure distances and compute the sides and areas of various figures, but they do not want to calculate the ratios between the different functions of the angle. Therefore, the great desideratum of surveyors and others who applied trigonometry to practical measurement, was to discover a centesimal division of the circle, or of a sector of it, that would give a simple percentage ratio between two sides of a right angle. For any triangle can be converted into two right-angled triangles by dropping a perpendicular on to its base, and then it may be solved as two right-angled triangles.

Descartes and all the great mathematicians foresaw that the discovery of such a percentage unit of angular measurement would immediately revolutionise and simplify to such an extent the science of practical trigonometry as applied to surveying, measuring and laying off angles; that anyone would be able to solve difficult problems in geometry, surveying and telemetry without the aid of mathematical tables. Such a percentage unit would effectually do away, in practice, with the abstruse method of dealing with "the functions of the angle" through their complicated ratio with the radius, and their still more complicated ratio of the sides of a triangle.

The Author felt assured, that the hope of finding this percentage unit, could only be discovered along new and untravelled lines, and would necessitate the absolute abandonment of the old methods of subdividing the circle. *The new unit* of angular measurement must be one that would subtend *a percentage of the radius*, and which would express the departure-angles of divergent lines as a percentage of the radius, or base-line from which the divergent lines parted. In this way the perpendicular of a right-angled triangle would always be that percentage of the base line expressed by the number of the percentage unit of angular measurement contained in the angle opposite it.

Groping along these lines, at first entirely in the dark, the Author suddenly grasped the fact, that the tangent of an octant was equal to the radius. Then by dividing this particular tangent into 100 equal spaces, and drawing lines from these spaces through the octant arc to the centre of the circle, each of the 100 octant divisions subtended exactly $\frac{1}{100}$ of this tangent *and* $\frac{1}{100}$ *of the radius.* Here at once was a calibration giving a centesimal ratio between an outer or tangential function and the radius. This calibration could be carried through 45° and must

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terminate at the end of the octant; but all the octants might be treated as whole numbers, and the centesimal divisions might be carried from each quadrantal line, through the adjacent octants in opposite directions, and thus inscribed round the entire circle. *In this way the solution of the centesimal division of the circle was solved by the centesimal divisions of the octant.*

Any angle could now be described in this manner—as a percentage of departure—in a given direction either on one side or the other of one of the quadrantal lines; and this percentage of departure was simply a percentage of the length of the radius. All angles would be measured from one of the quadrantal lines, from which the calibration starts and the divisions would be numbered from 1 to 100 (C).

The Author has named the quadrantal lines *Quadrantal Base-lines*, because every angle must be measured from one of these lines. They are in reality the zero of the circle. To illustrate the use and advantages of this system, take the following example :—

Set the quadrantal base-lines facing the cardinal points of the compass, and let the indicator of the circle mark an object as North 12 divisions East. *This course may be expressed in the terms North* 12 *per cent. East, for it evidently diverges East from North at the rate of* 12 *feet East for every* 100 *feet North.* Now, if you tell a man to step 100 paces towards a certain object and then step 12 paces to the right, he would immediately understand your instructions and can easily carry them out; but if you told him to go 12 degrees to the right of the same object he would not know how far to the right to go.

In the first instruction you used the Author's percentage unit of angular measurement, which so clearly expressed and defined the exact direction of the course, that a child might follow it.

In the second instruction you used the old method with the degree as the unit of angular measurement; but the actual value of the degree as a measure of departure from a fixed point is indefinite, and can only be expressed by mathematical formulæ, which give the value of a function of the angle, such as the sine or the tangent. No one can mentally convert circular measurements expressed in degrees into two lineal measurements that alone will clearly express the amount of departure of a course from a fixed object or a meridian. Here at once the advantage

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of the Author's percentage unit of angular measurement becomes apparent. Another most valuable advantage in the Author's circle is that it is a telemeter circle.

Again, by dividing half of a circle into degrees and the other half into octants and the Author's percentage units, angles may be measured and read in degrees, minutes and seconds on one half and in the Author's percentage units on the other.

The Author has published a little book entitled 'Fergusson's Surveying Circle and Percentage Tables,' which illustrates, by a number of simple rules, examples and diagrams, the method of solving many problems in surveying, range-finding, levelling by angles, and setting out curves of any radius—*by simple arithmetic.* The limits of this paper will only permit a few rules and examples to further illustrate the subject.

Example I.—When the space, subtended by any single division of the octant, on an off-set laid off at right angles to the quadrantal base-line can be measured, or read directly through a telescope, then, this space multiplied by 100 *gives the distance of that off-set along the base-line or radius from the angular point.*

In Fig. 1, Plate I., A B represents the quadrantal base-line and B C a tangent off-set. Let the space *d e* measure 1 foot on the tangent off-set B C, and subtend 1 division at the angle A. Then the distance A B will measure 100 feet.

As each division of the octant covers equal spaces on the tangent off-set, 3 divisions, at the angle A, would cover 3 feet on the tangent off-set B C, and $\frac{3 \times 100}{3} = 100$. In this way a mean reading of both the tangent off-set and the instrument is obtained. Hence the formula:

$$\frac{\text{space on tan} \times 100}{\text{number of divisions subtended}} = \text{radius.}$$

Example II.—Should the quadrantal lines of the circle be set facing the cardinal points of the compass, as in Fig. 2, *Plate I., and the object* C *lay North* 40·80 *per cent. East.* Find the Distance, the Latitude and Departure of the object.

Let the space covered anywhere along the tangent off-set B C by three divisions of the octant equal 6·87 feet, then $\frac{6{\cdot}87 \times 100}{3} = 229$; the Northing of the course A B.

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The Easting of the course A C is the distance B C = 40·80 per cent. of the distance A B; and 40·80 per cent. of 229 feet = 93·63 feet.

But Northing is latitude, and Easting is departure; so we have:

The direction of C = North 40·80 per cent. East.
The latitude of C = 229 feet North.
The departure of C = 93·63 feet East.

This method does away with the necessity of traverse-tables for determining the latitude and departure of a course.

NOTE.—Should a space on a tangent off-set be subtended by a decimal portion of a division on the octant arc (thus 2·48 feet by decimal 8 of a division)—simply multiply by 1000 and divide by 8 as $\frac{2480}{8}$ = 310 feet, the length along the base-line.

Example III.—To find the direct distance of an object C *from a station* A, *with the azimuth circle* (*see Plate II.*), *proceed thus*:—

Set up the instrument over station (Fig. 3, Plate I.) with the instrument plates clamped at the quadrantal base-lines.

Sight C. Now the line of sight A C is directly along the quadrantal base-line of the instrument; so read the space covered on a tangent off-set or rod C D by one or any number of divisions; say three divisions cover 7·42 feet, then $\frac{1}{3}$ (7·42 × 100) = 247·33, the distance along the quadrantal line, which is the distance over the course A C.

NOTE.—With a small compass, and vanes attached to a levelling rod, there is no difficulty in pointing a rod East and West or holding it at right angles to the line of sight through the instrument. Direct distances up to 300 or 400 feet can be got as easily by the vertical circle from a rod held vertically, as explained in the following example.

Example IV.—With the vertical circle (*see Plate III.*) *to get the distance and difference of levels between two stations. Let f and g be two station pegs.*

Set up an instrument over peg *f* (Fig. 4, Plate I.); level the plates and the telescope; then the indicator will mark the circle at B B, and the line of sight through the telescope along the line B B is the quadrantal base-line, and is parallel with the horizon.

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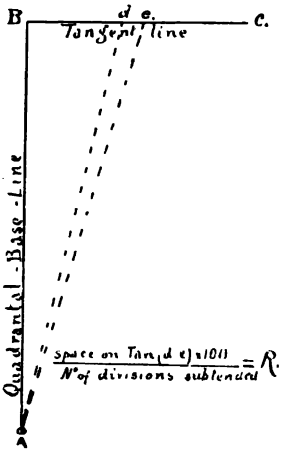

Fig 1

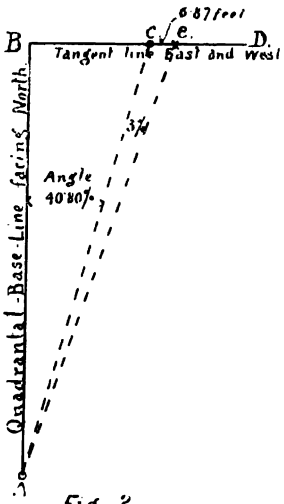

Fig. 2

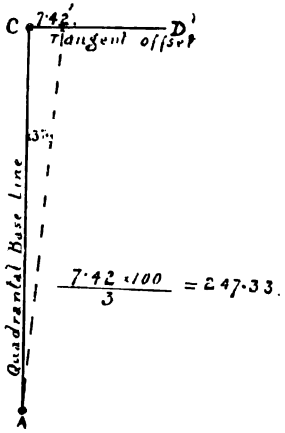

Fig 3.

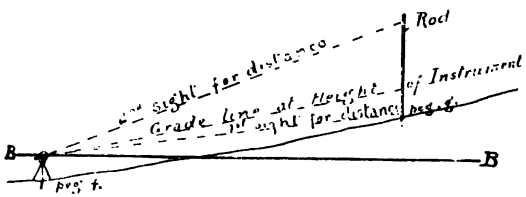

Fig 4.

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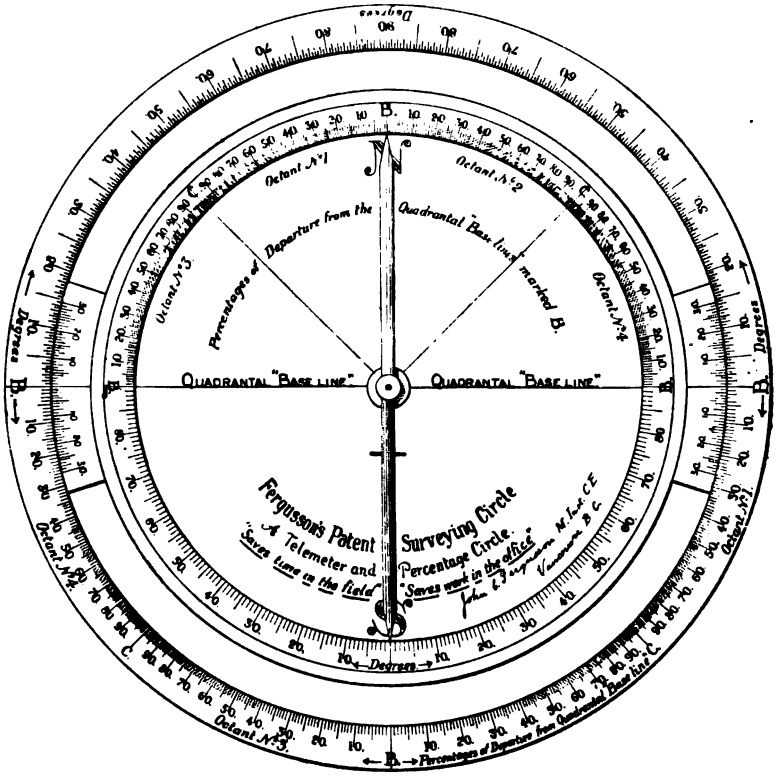

CIRCLE IN AZIMUTH.

Note.—This figure shows the upper and lower plates of a transit theodolite, with opposite verniers, but with the telescope removed in order to show more clearly the compass dial, azimuth circle and opposite verniers.

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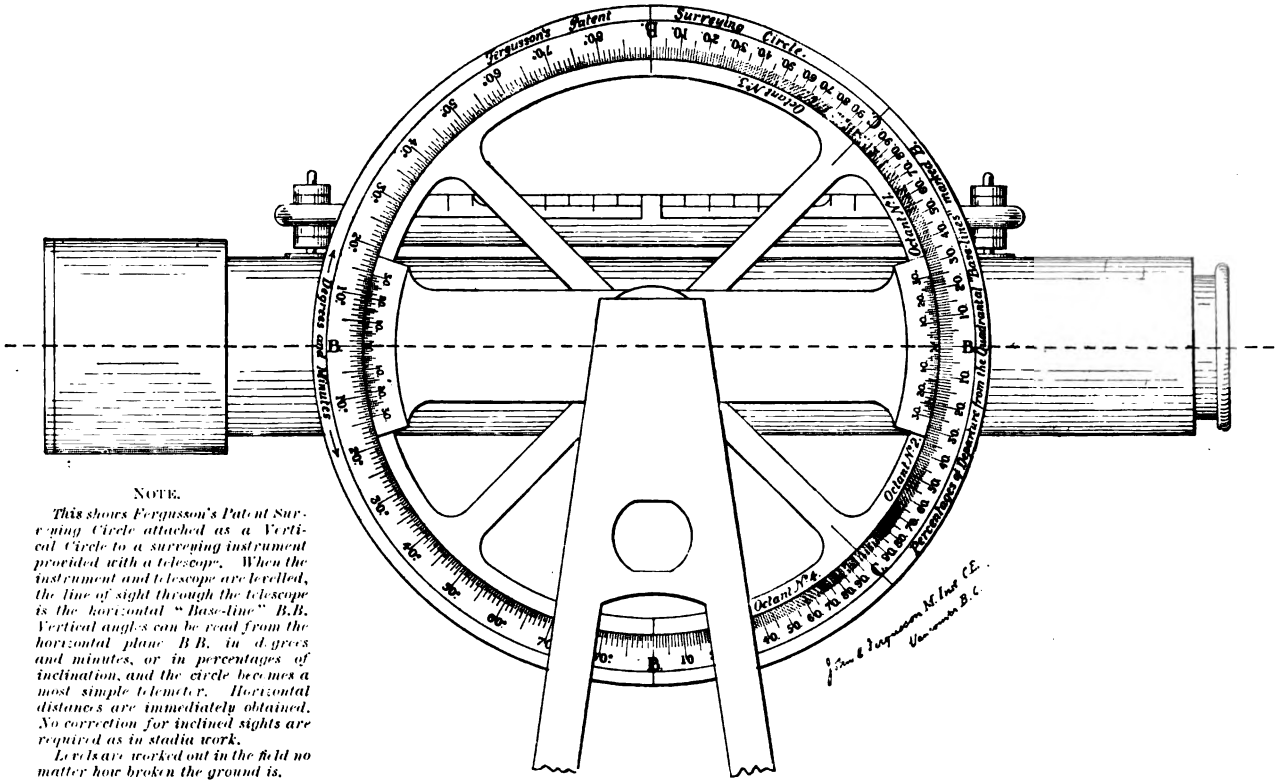

VERTICAL CIRCLE.

NOTE.

This shows Fergusson's Patent Surveying Circle attached as a Vertical Circle to a surveying instrument provided with a telescope. When the instrument and telescope are levelled, the line of sight through the telescope is the horizontal "Base-line" B.B. Vertical angles can be read from the horizontal plane B B. in degrees and minutes, or in percentages of inclination, and the circle becomes a most simple telemeter. Horizontal distances are immediately obtained. No correction for inclined sights are required as in stadia work.

Levels are worked out in the field no matter how broken the ground is.

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Let the height of the instrument above peg *f* (Fig. 4, Plate I.) be 2·75 feet.

Clamp the telescope at an even number of divisions, and read the rod near the bottom; then unclamp the telescope and elevate it through three divisions of the octant, and again read the rod. Say the space covered on the rod by these three divisions, through which the telescope has been raised, is 9 feet on the rod; then by the formula:

$$\frac{\text{space on tan} \times 100}{\text{number of divisions subtended}} = \text{radius or distance}$$

$$\therefore \quad \frac{9 \text{ feet} \times 100}{3} = 300 \text{ feet.}$$

The true horizontal distance between the station pegs *f* and *g*.

Now sight the telescope exactly on the figures 2·75 feet on the rod, which is the height of instrument, and read the octant angle. Say it reads 3·25; this is the grade line between the tops of the pegs *f* and *g*. The difference in level between pegs *f* and *g* is 3·25 per cent. of 300 feet = 9·75 feet.

NOTES.

1. The Author's surveying circles can be fitted to old instruments, as well as to new ones in place of the old circles divided only in degrees; and where this is done any surveying instrument is at once converted into a telemeter or range-finder.

2. No correction is required for the reading of the rod through inclined sights, as in stâdia measurements.

3. Any angles read in the Author's percentage unit of angular measurement can be plotted by laying off a rectangular off-set with any scale of equal parts, without either a protractor or traverse-tables.

4. The system of reading the tangent space on any rod, chain or measure, through several divisions of the octant arc, is very accurate.

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DISCUSSION.

The PRESIDENT: I should like Mr. Fergusson to tell us whether he can have his circle so put on that he has full advantage of both systems and can use either, and whether it can be fitted to old instruments.

Mr. T. CAINK: The difficulty that presents itself to me is the application of the vernier to the circle, because the divisions on the octant varies from nothing up to 45°, and that seemed to me to make it impossible by the vernier. I did not follow Mr. Fergusson in the application of the screw. I should like to ask what is his method for obtaining a line at right angles to the base.

Mr. J. PRICE: I may say I am only sorry this instrument did not exist when I was a railway engineer, as this system would have been of very great assistance indeed. The question that naturally arises is, what is the cost of putting this circle to an existing instrument, because I do not suppose every one is in the same position as our President, with a great Corporation behind him. But I dare say there are some who might be able, if it is within reasonable means, to add the circle to their instruments.

The PRESIDENT: The point is this. A good many of our members have a theodolite and want to adopt this circle, and the question is whether this circle can be put on the old theodolite, and what is the cost.

Mr. J. C. FERGUSSON, in reply, said: The percentage circle can be applied to old instruments, as the old circle, divided on silver, can be removed, and new circles divided according to my method (which would read angles both in degrees and in the percentage units) inserted in their place. When this is done any surveying instrument is immediately converted into a simple telemeter instrument. These circles are made by Messrs. T. Cooke and Sons, of 8 Victoria Street, London. The cost of a new instrument is about 38*l*. The cost of attaching new circles only to old instruments is about 3*l*. 10*s*. Micrometer tangent screws, for reading the octant divisions to $\frac{1}{100}$, cost 1*l*. As to the accuracy with which the percentage divisions can be read, in comparison with the degrees, which are read by a vernier, I would point out that the tangent screws attached to

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both the vertical and azimuth circles, carry a scale divided and numbered from 0 to 100. One complete revolution of this micrometer screw passes the instrument exactly from division 0 to 1, and without perceptible error between all the divisions up to division 8. Referring to the percentage tables, it is found that ·91 or $\frac{1}{100}$ of a revolution of the tangent screw registered about 20 seconds, and that was as close as a 5-inch instrument, such as I am showing, can be expected to read. The micrometer screw is not a new method of reading small measurements of space, but it is one of the most accurate means we possess of reading minute distances; it is more accurate than the vernier, and can be more quickly and accurately read, therefore I have adopted it.

In reply to Mr. Caink: Although fractions of my percentage units cannot be read with the vernier because the divisions are unequal, a minute fraction can be read by the micrometer tangent screw as explained. I have stated that the micrometer registers hundredths of a percentage unit without appreciable error between numbers 0 and 8; above those numbers a micrometer registers less than a complete revolution of 100 on the scale; but the number of hundredths of the scale contained between the higher numbers of the octant can be obtained by manipulation, thus: supposing it was necessary to record a fraction of a division between the divisions Nos. 49 and 50. In passing the index of the tangent screw between 49 and 50, it was found that there were only 80 numbers on the scale recorded; now, if the scale read 49 and 20 on the micrometer scale, these numbers were $\frac{20}{80}$, so the accurate reading of the sight would be $\frac{20}{80}$ or $\frac{1}{4}$, or 49·25. In reading inclined sights when the instrument and telescope are levelled, the base line is the line of sight through the telescope. When reading the levelling rod, it should be remembered that the rod only forms a small portion of the tangent, which was an imaginary vertical line starting from the base line and extending upwards through one octant, or 45°. The rod is merely made use of for reading a small space on the tangent. There is no correction needed for the rod in inclined sights, as is required when stadia measurements are taken, with a circle divided into degrees. As every percentage of the octant covers equal spaces on the tangent, it is evident that, if the engineer is not satisfied with the reading of the rod, through only one whole division of the octant, he

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could read the space subtended by 3, 4, or 5 divisions, and multiply the space so covered by 100 and divided by the number of divisions subtended. This method gives very accurate results, for it gives a mean reading of both the rod and the instrument. In practice I have found this was a more accurate method of reading distance than by stadia-wires. The percentage unit does away with that great bugbear of surveyors, the traverse-tables. The instrument is in itself a complete traverse-table machine. The percentage unit records the length of the departure of the diverging line from the base-line; and this departure is always that percentage of the base-line expressed by the number of the percentage unit at the angular point. An angle of 12 per cent. can be laid out with any scale of equal parts by laying down 100 parts and making an offset at the end of those 100 parts, of 12 parts; if a piece were broken off the scale and it did not contain 100 parts, then one could mark off 50 parts and an offset of 6 parts. There is no difficulty in laying out a tangent line at right angles to the course. The degree of accuracy that can be attained in taking measurements depends upon the instruments and methods employed. A distance can be measured with a steel chain; but if greater accuracy be desirable it would be better to use a steel tape marked into $\frac{1}{100}$ of a foot.

The PRESIDENT: I must thank Mr. Fergusson for contributing this paper, and for the exceptionally clever way in which he has explained all these points.

The Members were entertained to luncheon by the Mayor of Wolverhampton.

The afternoon was devoted to an inspection of the Lorain surface contact system of electric tramway traction, and a visit to the Exhibition.

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ANNUAL MEETING AT BRISTOL.

July 10, 11 and 12, 1902.

THE PRESIDENT'S ADDRESS.

By T. H. YABBICOM, M. Inst. C.E.

It is with peculiar satisfaction to myself that I am the first President of this Association to have the privilege of addressing an Annual Meeting of the extended franchise, and it is not without its significance that the first meeting embracing not only Members by virtue of their responsible positions as officers holding chief permanent appointments, but also the young and vigorous outgrowth of those holding more subordinate positions, to whom we must look for help by their strength, energy and enthusiasm, and who will by their tact and prudence prove themselves ere long capable of wearing the mantles that must drop from other shoulders, should be presided over by one who, while holding a subordinate position, knocked for many years, but knocked in vain, at the portal of this Association. I therefore gladly welcomed the spirit of progress which gradually, and at first slowly, breathed over the minds of our Members, culminating in the resolutions adopted at the last Annual Meeting. It was natural that such an important change in the constitution of our Association should meet with a certain amount of opposition, but this was decidedly beneficial as it ensured a more searching examination of all the arguments for and against the proposal and a closer investigation, and therefore avoidance of, the hidden rocks on which the newly commissioned ship might have suffered wreck. As President, I say that the Association hopes and expects a large addition of strength, and the opening up of new channels of usefulness by the admission of the Class of

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Associates, not so much by the numerical increase to its ranks as by the introduction of new blood instinct with enthusiasm and the desire for progress, which, combined with thoroughness, is the concrete foundation on which all improvement in engineering rests. If, however, the advantages of the change will be great to the Association, we venture to hope they will be equally so to those younger members of the profession who are now united with us in fellowship, and that while they view things with the more ardent enthusiasm fitted to their years and hopes, will not disdain to profit by the experience of those who have already borne the burden and heat of the day, whose prudence may at times appear vexatious, and whose caution may seem to approach timidity. One central point to be kept before us in our deliberations is that whether as Members or Associates of this important body of Municipal Engineers we shall strive our utmost to improve and extend our knowledge by intercommunication for the benefit of the Councils that have entrusted us with the performance of the duties pertaining to our offices. In this way, and in this way only, can we justify to those Councils our existence as an Association: a justification that has been fully recognised for many years not only by the municipal bodies of our large cities, but by the smaller, though relatively important district and parish councils, all forming integers in the local government of the country. We must press home to our rulers that we do not combine in any way for self aggrandisement; that we have no idea of forcing upon them claims in favour of the Members, as Members of the Association, which they would not be willing to admit to the individual; that in fact we are not united for any selfish wish to do good to ourselves except so far as that in improving ourselves we are enriching our governing bodies by bringing to bear upon our daily practice the accumulated experience derived from the whole body. Now if these are the sentiments—and I firmly believe they are—which actuate the great majority of our Members, it becomes our duty to this Association to do no act as individuals which may weaken its influence for good with the Councils which manage the local affairs of the Empire. I use the word "empire" because, as you are aware, our Members are not drawn only from, or its sphere of usefulness confined to, Great Britain and Ireland, but include many brothers holding municipal appointments in the cities of Greater Britain who have problems

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to solve and difficulties to contend with, which we, under our more favoured conditions, can hardly realise, but on which they are able to bring to bear the experience and knowledge acquired in the municipal government of this land.

It is difficult to leave this part of my subject without referring to another important change recently effected by this Association by which it has deprived itself of the advice on the Council of some who for years have assisted at its deliberations by their experience. The theory that the affairs of the Association should be managed only by those actively engaged in municipal work is sound, but one result of the new bye-laws may be to exclude from our Councils some to whom the Association owes its creation and others who have assisted in raising it to its present successful position. Whether the crew will be able to steer the bark successfully without the aid of the old pilots is a question which will be watched with interest.

As the council, whether borough, county, district or parish, is the body by whom the surveyor has been placed in his position of responsibility, it is to the council that he looks for support to enable him to carry out his duties, and its reception should be met by him with unswerving loyalty. The discipline that he has received with his training has taught him that the orders issued by the council are to be executed without question; the council, having deliberated and come to a decision on any matter, are the persons who will have to answer for their acts to the body of ratepayers, and the surveyor's duty is to obey; but discipline not combined with loyalty must result in only a calculating head service, without the warmth of the heart required for thorough obedience. A council is at its best but a fortuitous agglomeration of persons usually actuated by genuine honesty of purpose, but some are furnished by their constituents with coloured glasses, and others are returned to advance specific objects. At times his council will be divided in opinion on a question of expediency, and the surveyor will find plenty of opportunities of displaying such tact as, it is to be hoped, he possesses, in steering clear of the rocks of faction. But the surveyor has a higher and nobler responsibility than simply to act as the agent of his council in carrying out their behests, or as the machine to prepare schemes and estimates; it is his duty, as recognised by every right-minded member, to advise where he thinks advice necessary,

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and should occasion require, and he be convinced of the righteousness of his judgment, to press home his opinions emphatically; but in that case he should, like Pliny, be able to say "experience has taught me, and experience is the finest master." It is quite unnecessary to say to such an Association as this that the surveyor should keep himself in the van of improvements and a pioneer to remove obstacles to advancement, and in this respect the admission of our younger friends will be laden with advantage; we all of us grow more conservative with our years and are inclined to look with eyes of affection on some work executed with good results in times past but which the march of improvement should leave behind or consign to the scrap-heap; the impetuosity of youth has no reverence for these antiquated machines, and would employ his time more profitably in constructing new ones better adapted, it must be owned, to the rapid age in which we live. There are, however, times and places where it becomes the duty of the surveyor to utter his note of warning against schemes fanciful and chimerical, or against schemes which while serving their purposes admirably in one place are unsuited to another.

Having given his opinions to the best of his ability, the surveyor must treat the council as a jury and loyally accept their decision. The probabilities are that very few if any of the members are experts, but the fact of holding the position they do indicates that they are possessed of rather more than the average of common sense unless they have been sent to the council as the exponents of any particular theory or supporters of any particular class; even these have their uses and can give an unprejudiced opinion on matters not connected with their own fads. Most members of the councils of the local authorities in this kingdom are actuated by the highest and most unselfish motives, and the few, who seek to use their position for the benefit of themselves or the advancement of their friends to the detriment of the public good, show up by contrast the brighter example of their fellows. Municipal government may not offer to those engaged in it the same brilliant prospects that are looked forward to with hope by those representatives at Westminster who make their mark in Parliament, but it does give a good citizen who has at heart the welfare of the place he lives in an opportunity to work for the benefit of his fellow burghers without reward and sometimes with but scant thanks.

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It is therefore the more noble that they continue to give their time and energy on works which involve the well-being, health and comfort of their fellow citizens.

From the nature and multiplicity of his duties the surveyor must be brought into daily contact with the numerous body who contribute, willingly or unwillingly—usually the latter—of their substance in order that the local machinery may be kept going, and it will depend very much on himself whether the result is perfect coincidence, or contact resistance.

There is in Englishmen an innate desire for just treatment, a wish to see the game played fairly, that usually prevents an individual or a small majority from taking advantage of a position he or they may have acquired to unreasonably harass and worry an official. Still we know that such things do sometimes occur, and a man of sensitive temperament has to suffer acutely for the, sometimes, unintentional pain inflicted on him by persons of robuster natures who cannot feel themselves, nor understand the distress of mind they impose on others. It is therefore of the utmost importance that the surveyor, whether of a large city or of a parish council, should so act in his relations with the body of ratepayers that it may be felt and acknowledged that all private interests are subordinated to the public good; there must not be the breath of suspicion that one matter of public importance is put aside because it may clash with the personal concerns of the individual. It is very easy to write this, and to wish that it may be so, but the surveyor knows only too well how the faithful exercise of his duties must bring him into conflict with men who contribute to his means of living, and occasionally meanly think that this fact gives them a hold over him. Nothing but the strictest impartiality can avail an official who is constantly called upon to administer laws restraining persons from doing things they believe to be harmless, or have from long custom come to think right, but which the modern investigations of sanitary science have declared inconvenient or dangerous to the community; laws directing them to do things costing sometimes considerable sums of money from which they apparently reap no personal benefit, but are intended for the gratification and satisfaction of the public; laws insisting that a man shall, in the interests of his work-people, build in a fashion that he does not think will enable him to get so much floor-space out of a given and

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restricted area as he had hoped to do; laws that insist upon the landowner, when laying out his estate, devoting ample space at the expense of ground-rents, for wide roads and ventilation in order that the light of the sun and the sweet breath of heaven may annihilate the bacilli that flourish and rejoice in darkness and stagnation; laws that compel an owner having an inflated idea of the value of his possessions to give them up for the public good at a value that the surveyor acting as a trustee of the public funds deems reasonable. It is all very well to say that the surveyor did not make the laws but has only to administer them: the fact remains that the advancement of the common benefits may press heavily on the individual, and for that reason it is necessary that the official carrying out these duties should act with discretion and consideration, while never losing sight of the fact that his first duty is to advance the interests of the community. "Though at the moment a loyal conduct of a case may offend those whom one is opposing, in the end it wins even their admiration and respect."*

The reception and dealing with complaints is another means by which the surveyor is brought into daily touch with the body of ratepayers and may be made an exercise, agreeable or otherwise, according to the way in which the complainants are treated. It may be conceded that those who pay have the right to grumble, and it is not a difficult task to ascertain whether the complaints are well-grounded or frivolous. If the complaint is on inquiry found to be justified, it is manifestly the duty of the responsible party to if possible do away with the cause of it; if it be of little weight, and the remedy worse than the disease, a stock of good temper is an admirable asset, especially if the person making the complaint is persistent. It is difficult for the most obdurate person to hold out against enduring good humour, for that is infectious, especially when it is backed by common sense. In the larger boroughs it is the assistant who usually has to see to the carrying out of remedies for the small vexations which worry the ratepayer, and it is no unimportant part of his duties, for he may easily bring his council and chief into bad odour with the public if he be careless or inclined to lightly treat what seems to him unimportant, but yet may be of much consideration to the individual; if, however, he be

* Hallam.

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thoroughly in earnest to do right in these small matters and applies the best principles to complaints from high or low alike, very few of his decisions will have to be reversed if an appeal be made to his chief.

Day by day the municipal engineer must be brought into contact with his brother officials serving the same local authority, and much of the success attending the execution of their duties depends on the loyal support accorded by one officer to his fellows. The duties of each should be so well defined as to ensure a total absence of friction in the working of the machine, and this end may best be gained by every member of the staff making up his mind to do his own work in the most thorough manner possible, and not to interfere with the actions of other people. The neglect of this useful principle has led to much discomfort and a loss of efficient working in many places which might have been avoided by the exercise of a little tact and forbearance. Officers of a local authority have it in their power to help one another immensely, and would do well to remember that each should, individually and collectively, do his utmost for the common good. The question of social intercourse among the officers of the same public body is one that must be left very much to circumstances; but I am of opinion that the habitual meetings of persons, having common aims, for the reciprocal exchange of ideas outside the hard and dry details of everyday business, has a beneficial effect in rubbing off the austerity of officialism, and laying bare the more human sentiment of sympathy.

I have been led to extend these remarks somewhat, because we now have in our ranks an important number of regularly trained members of our profession already doing good work as assistants, who will probably, in the near future, occupy chief appointments; and the experience of a life spent in municipal work has taught me that nothing can be accomplished without thorough honesty of purpose, tempered by a generous consideration for the opinions of others. The work of the municipal engineer may not be so showy or reap such golden rewards as that done by other members of the engineering profession, but of late years the public has been brought to acknowledge the importance of a branch on which they depend so largely for their daily comfort, convenience and even luxuries, and above all for those works for the prevention of the spread of disease,

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and inducing a healthy, vigorous tone without which the workers of our great centres of civilisation are sapped of their vitality and energy.

In conclusion, I wish to thank you most cordially for having conferred upon me the highest honour which this Association has at its disposal, and to ask that in the coming year you will give to me the same valuable assistance in carrying out the duties of my office that has been accorded by the Council and Members generally to former presidents.

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TWENTY-FIVE YEARS OF MUNICIPAL PROGRESS IN BRISTOL.

By T. H. YABBICOM, M. Inst. C.E., City Engineer.

It has been usual to lay before the Members of this Association a statement of the municipal works executed in the town in which they foregather for their annual conference, but it is not the intention of the writer to weary his fellow Members with details of the miles of highways and sewers that he has to superintend, or the number of houses built last year. It may be, however, interesting to note the changes that have taken place in this ancient city since the last visit of the Association at an annual meeting in 1877. Twenty years after that date, an important extension of the city boundaries was sanctioned by Parliament, other smaller extensions have been granted in 1895 and 1901, and the area of the city has increased from the 4687 acres of 1877, to 11,607 acres at the present time. At your last meeting in Bristol the population was estimated at about 203,000; it is now estimated at 334,632. The rateable value was then 772,623*l.*; it is now 1,596,213*l.*

The success of the city is largely bound up with the Docks; Mr. Ashmead's paper, read in 1877, described the works executed in the early part of the nineteenth century by a private company, but acquired by the Corporation in 1848, the policy of this action being shown by the fact that the tonnage of foreign imports increased at once nearly fourfold under the civic management.

The increased size of vessels after the introduction of steam as a propelling power intensified the dangers of the navigation of the narrow and tortuous river Avon, and docks were constructed by private enterprise on both sides of the mouth of the river where it joins the estuary of the Severn. These docks were also acquired by the city in 1884.

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The tide in the Severn at Avonmouth ranges 42 feet at ordinary spring tides, and 24 feet at ordinary neap tides.

The difference in level between high and low water is sometimes as great as 49 or 50 feet.

The total water area of the City docks is about 83 acres, including Cumberland basin 4½ acres, and Bathurst basin 2 acres. The area is made up as follows :—

Float.—Below Bristol bridge, including Bathurst wharf and Grove—	
Cumberland basin and locks	4½
Merchant's dock and floating harbour to Prince's Street bridge	42½
Prince's Street bridge to Bristol bridge	12
Above Bristol bridge, including Totterdown basin ..	14
Feeder.—Feeder canal (and part outside lock)	7¾
Bathurst basin	2
	82¾ (say 83) acres.

The length of quays at the City docks is 4½ miles gross; net wharfage, 3600 yds.

Hydraulic Machinery.—The power for working the machinery in connection with the dock gates, sluices, capstans, swing-bridges, hydraulic cranes and granary machinery is supplied by two sets of Worthington pumping engines, each of 180 horse-power, situated at the Underfall yard. The power is also supplied from these engines for working the Vauxhall swing-bridge across the new cut, and by reducing the pressure the main engines can be used as fire-pumps in connection with the fire service at the Granary.

The normal level of water in the floating harbour is 19·78 O.D.

The floating harbour is supplied with fresh water from the river Avon through the feeder canal and by the river Frome, the whole discharge of which is emptied into the floating harbour. Flood waters are disposed of through large sluices communicating with the new cut, and in dry weather, when the waters of the Frome are below the level of the floating harbour, the communication between the Frome and floating harbour is closed by means of gates, and the Frome waters conveyed into the new cut by an independent culvert.

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The Avonmouth Docks.

The existing dock was built by the Bristol Port and Channel Dock Company under their Act of 1864, and was purchased by the Corporation in 1884. As originally constructed, the dock was 1400 feet in length and 500 feet in width; it was enlarged in 1894. The extension is 800 feet in length by 180 feet in width. Total water area, including extension, 19 acres.

Lock.—The sill level is 15·58 below O.D. The depth of water on sill is 38 feet at ordinary spring tides and 28 feet at ordinary neap tides. Length, 454 feet between inner and outer gates. The length of the quays is about 1 mile.

The total area of shedding is 59,340 square yards and of granary 21,262 square yards. Accommodation is provided at the cattle lairs for 700 head of cattle and 4000 sheep. Chill rooms capable of taking 700 sides of beef are worked on the ammonia absorption system, and 110,000 cubic feet of capacity of cold storage are provided worked on the Linde ammonia compression system.

The wharves and sheds are lighted throughout by electricity, supplied by three continuous-current dynamos, each of 37 kilowatts, and one of 16 kilowatts.

A pontoon dock has been provided, 365 feet in length and 62 feet clear width between the side towers; it is capable of lifting a vessel of 3800 tons dead weight.

The Portishead Dock.

This dock, situated on the west side of the Avon at its confluence with the Severn, was built by the Bristol and Portishead Pier and Railway Company under their Act of 1871, and was purchased by the Corporation in 1884. The water area is 12 acres, and the depth of water on the sill of the entrance lock is 34 feet at ordinary spring tides and 24 feet at ordinary neap tides. The length of the quays is $\frac{1}{3}$ of a mile. The granaries have a capacity of 80,000 quarters.

Dredging Plant.

In consequence of the large amount of solids held in suspension in the waters of the rivers Severn and Avon, constant

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dredging is required both in the river Avon and in the docks. At present there are five dredgers at work, capable of lifting an aggregate of from 800 to 1100 tons per hour.

Dock Extension.

For a number of years a series of fierce battles was fought over rival schemes for dock extension or for converting the river Avon into an elongated floating dock by placing a dam across its mouth; but last year a Bill was obtained which sanctioned an expenditure of something like two millions sterling on dock extension at Avonmouth. The work has been auspiciously commenced this year by the visit of the Prince and Princess of Wales to cut the first sod on March 5.

The scheme comprises a dock of about 1000 feet square, with an arm 700 feet long, at the end of which will be a passage communicating with the existing Avonmouth dock, and it is intended in the future to construct two other arms or bays about 1500 feet in length, with a jetty or mole between them. The present contract, however, is for the large bay of the dock, the arm, and the communication passage.

The dock will be approached from King Road through a channel, on each side of which are piers of about 1000 feet in length, leading to a lock 850 feet long. The sills of the lock afford 36 feet of water at high water ordinary neap tides, and 30 feet of water two hours before high water ordinary neap tides. At high water of spring tides there will be about 10 feet greater depth.

The water area of the portion of the dock to be constructed under the present contract is about 30 acres, and there will be about 230 acres of land in close proximity to the dock.

The contract, which has been let, includes a large graving dock 850 feet in length and sea walls enclosing spacious wharves and storage ground.

At the extremity of the northernmost of the two entrance piers, a lighthouse is to be erected in place of the existing Avon light.

The wharves will be equipped with upper storied transit sheds and a complete system of railway sidings connected directly with the Midland and Great Western Railway Companies' systems.

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It is intended to provide cranes, elevators and other appliances for the rapid handling and despatch of import cargoes and for the shipment of export cargoes; and the space available for storage of timber and other merchandise is on a large scale.

The following are some of the leading particulars of the new dock as supplied to the writer by Mr. W. W. Squire, M. Inst. C.E., Docks Engineer.

LEVELS.

Description.	Depth of Water.			
	In Entrance Channel.	On Sills.		In Dock.
		Outer.	Inner.	
H.W. ordinary spring tides	47·00	46·00	36·00	35·00
Two hours before H.W.O.S.T.	35·00	34·00		
,, after H.W.O.S.T.	35·00	34·00		
H.W. ordinary neap tides	37·00	36·00	26·00	25·00
Two hours before H.W.O.N.T.	31·00	30·00		
,, after H.W.O.N.T.	31·00	30·00		
Half tide	25·00	24·00		

MEASUREMENTS.

Work.	Unit.	Amt.	Remarks.
Area of water space in the dock	acres	30	
Area of land in proximity to the dock	,,	230	
Length of quays including slopes ..	feet	5030	slope N. end, 1000 ft.
,, ,, excluding slopes ..	,,	3330	slope N.W. side, 700 ft.
Length of dock	,,	1120	average.
Width of dock	,,	1000	
Length of arm—East wall	,,	700	
,, ,, West wall	,,	500	
Width of arm	,,	250	
Length of cut	,,	525	
Width of cut	,,	80	
Length of lock between inner and outer gates	,,	850	
Width of lock	,,	85	
Length of entrance pier, No. 1 (South)	,,	900	
,, ,, ,, No. 2 (North)	,,	1050	outside.
,, ,, ,, ,, ,,	,,	1200	inside.

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Sewers.

One effect of this rather prolonged discussion on the nature and situation of the extension of the docks has been to leave the sewers question very much in the condition in which it was in 1877.

When the Members of this Association last held their annual meeting in Bristol in that year, the late chief, and valued colleague of the writer, described at some length the system of sewers that had been constructed by his advice up to that date. That paper is published in Vol. IV. of the Transactions of the Association, and it will not be therefore necessary to do more than refer to it. Broadly speaking, the principle of the design was that all the main sewers draining the various districts, into which the city, as it then existed, had been divided were constructed to discharge the sewage by gravitation into the tidal river, and were all built at such a level that the sewage might be concentrated at one or two points, either for treatment or for carrying by main trunk sewers into the estuary of the Severn, and had dockization of the river Avon been decided on, it would have been necessary to have removed all sewage below the dam before commencing. In 1899 the writer, in conjunction with the late lamented Mr. W. Santo Crimp, prepared a scheme for dealing with the sewage not only of Bristol, but of the Avon Valley as far as Bath, by a discharge into the Severn; but docks were occupying people's minds, and it has been aptly said that an Englishman can think of one thing only at a time. So it was that the popular vote was against the scheme, which will have to be revived, in probably a somewhat altered form, to meet altered circumstances, before a very distant date. Every summer brings with it a crop of indignant complaints of the discharge of crude sewage into the river within the city, and every winter effaces to a great extent the memories of the faded perfumes. There is no doubt that the low death rate and comparative freedom from zymotic diseases enjoyed in this city is due to a great extent to the scouring action of the tide, that rises at springs to 34 and 36 feet above low-water at Cumberland Basin, and with its ebb carries the sewage with it. The writer does not, however, wish it to be understood that he advocates a continuance of this crude system of sewage disposal.

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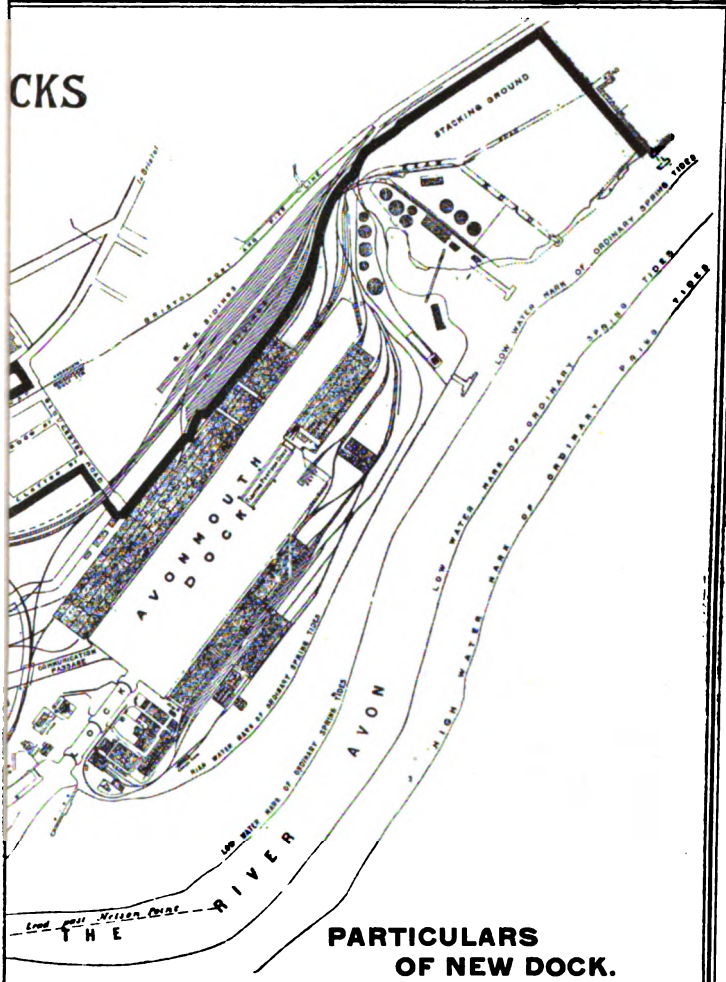

PARTICULARS OF NEW DOCK.

LEVELS.

ON.	Level above or below O.C.B. Datum	Level above Parliamentary datum 50 feet below O.C.B. datum	DEPTH OF WATER. In Entrance Channel.	On Sills. Outer	On Sills. Inner.	In Dock.
ring Tides	30.00	80. 0	47.00	46.00	36.00	35.00
H.W.O S.T	18.00	68.00	35 00	34.00		
W.O.S.T.	18.00	68 00	35.00	34 00		
ap Tides	20.00	70.00	37.0	36.00	26.00	25.00
H.W.O N.T.	14.00	64.00	31.00	30.00		
W.O.N.T.	14.00	64 00	31.00	30.00		
.. ..	8.00	58.00	25.00	24.00		
ck	38.31	88.31				
ck	-5.00	45.00				
.. ..	-6 00	44.00				
.. ..	-16 00	34.30				
e Channel	-17.00	33.00				

MEASUREMENTS.

WORK.	Unit.	Amt.	REMARKS.
Area of water space in the Dock	Acres	32	
Area of land in proximity to the Dock	Acres	230	
Length of Quays including slopes	Feet	5030	[1000 ft. Slope North end
L'th of Quays exc. slopes	Feet	3330	Slope. NW. side
Length of Dock	Feet	1120	Average (700 ft.
Width of Dock	Feet	1000	
Length of arm—E. Wall	Feet	700	
Do. West Wall	Feet	500	
Width of Arm	Feet	250	
Length of Cut	Feet	525	
Width of Cut	Feet	80	
Length of Lock between inner and outer gates	Feet	850	
Width of Lock	Feet	85	
Length of Entrance Pier.			
Do. No. 1 (South)	Feet	900	
Do. No. 2 (North)	Feet	1050	Outside
Do. do.	Feet	1200	Inside

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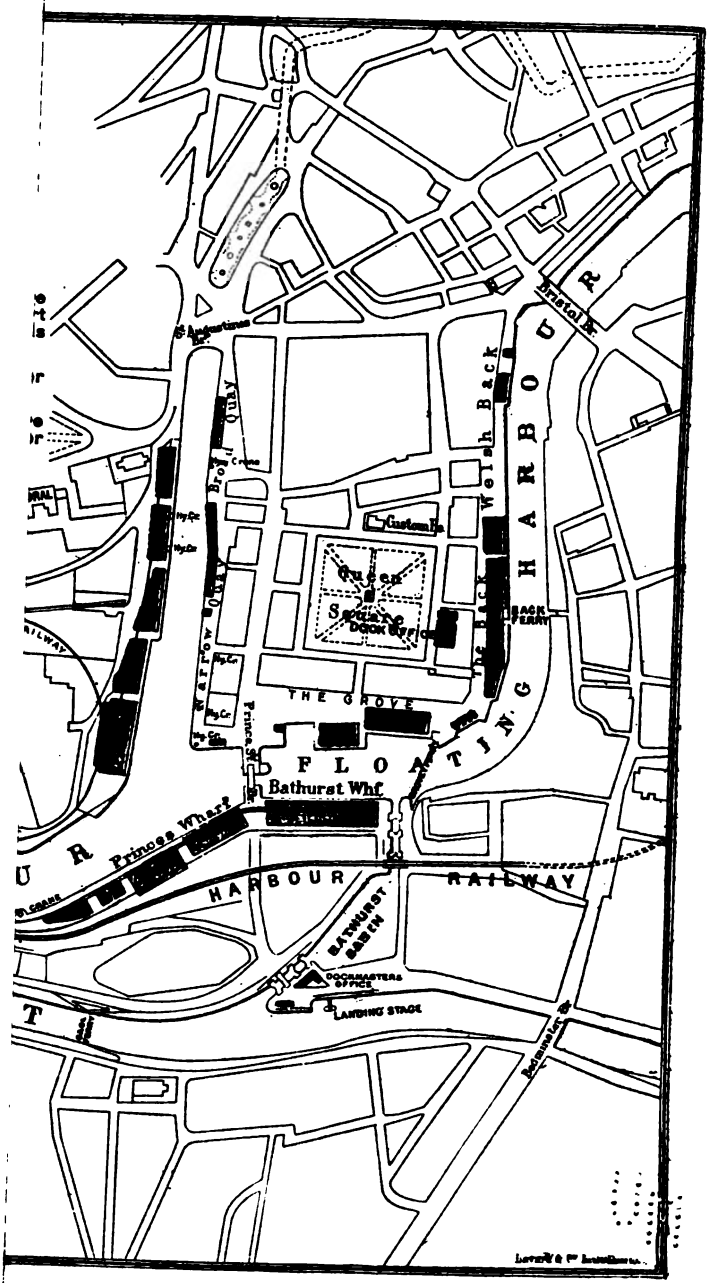

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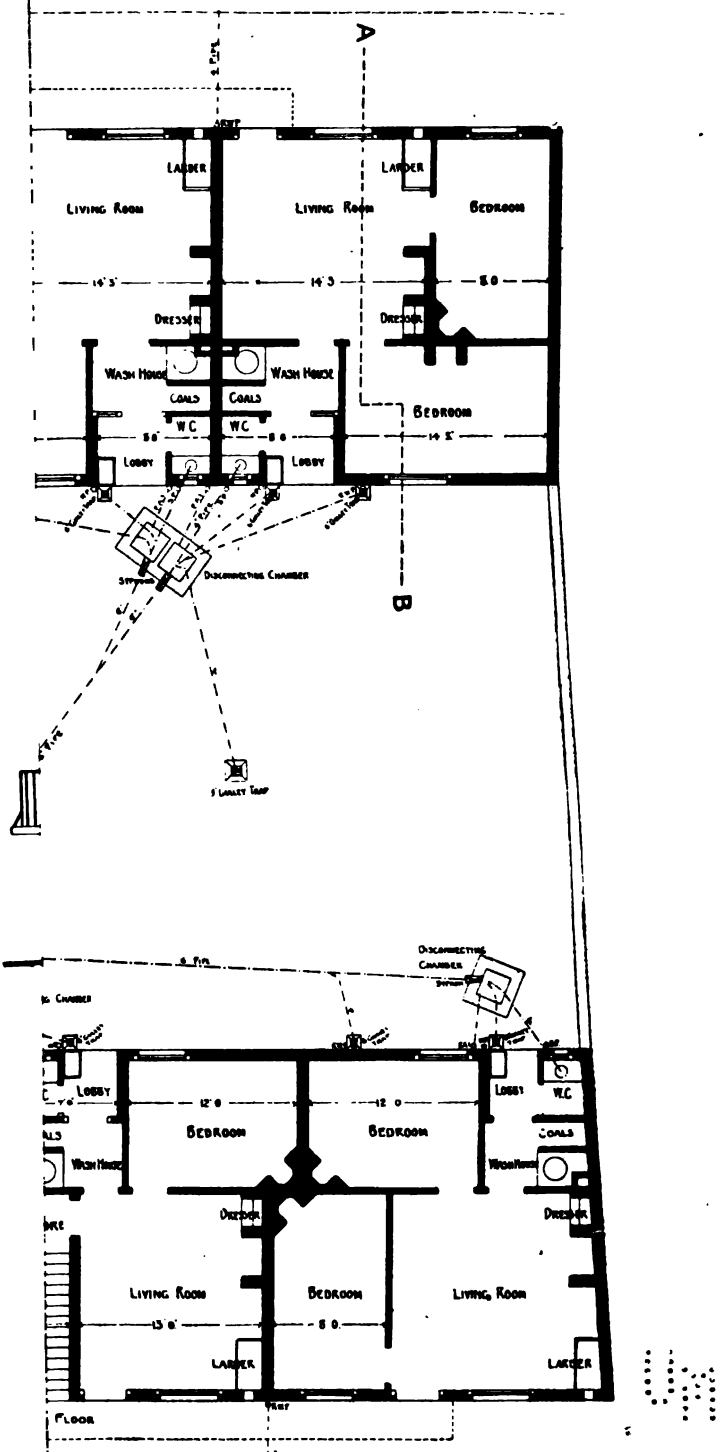
PLATE III.



GROUND FLOOR PLAN

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Street Improvements.

The narrow, crooked streets of Bristol have truly been a bye-word and a reproach, but these were failings that it possessed in common with all mediæval cities. Unfortunately the valuable efforts of the New Streets and Improvement Committees to make new, or widen and straighten old thoroughfares, while they have admitted light and air, convenience and utility, have sometimes resulted in the loss of many picturesque "bits" of civic architecture and historical connections. The Corporation has kept steadily improving and widening such streets as the nature and amount of traffic required, and since your last visit in 1877 has spent nearly 1,000,000*l.* in these works, including the construction of bridges across the river, and in addition to about 200,000*l.* expended in minor improvements in setting back projections.

Public Parks.

It was probably due to the possession of the magnificent recreation grounds known as "The Downs" on the north-west of the city, having an area of 442 acres, which were made over to the city before 1877, that the want of people's parks was not earlier felt; but as the population increased eastwards and southwards, it became necessary to give the inhabitants of those parts spaces in which they could enjoy fresh air and amusements without going a considerable distance. The first of these public recreation grounds was commenced in 1882, and since that date thirteen others have been added, varying in size from a quarter of an acre to 70 acres, most of them situated in the very congested districts. The total area of the public parks and open spaces is now 678 acres.

Baths.

Since 1877 the Baths Committee have built or acquired six establishments, each having swimming baths, and is now constructing another in the east end of the city, that will be provided with some of the most modern appliances that experience has shown to be necessary for the health and cleanliness of the people, including swimming, slipper and spray baths. The contracts for the builders' and engineers' works amount to upwards of 16,000*l.*

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Works for Floods Prevention.

The old city was built in a basin surrounded by hills, the natural land drainage being by numerous watercourses emptying into the rivers Avon and Frome, which flow through the city. Unchecked interference in the past with these natural means of drainage produced the usual results of serious floods in the low-lying districts as recently as 1889. Since that date important works have been executed in deepening and straightening the natural channels, and in providing shorter and more capacious culverts for quickly carrying off the storm water brought down from the hilly country around the city, with excellent results. Within the city a culvert has recently been constructed, but this will form the subject of a separate paper by the deputy city engineer, Mr. Steele, A.M. Inst. C.E.

Electric Lighting.

An Electrical Committee of the Corporation was constituted in 1884, who for the first few years contented themselves with marking time and watching the results of experiments made by others. In 1890 a small scheme for electric lighting was formulated, and a generating station commenced at Temple Backs. The results both in street and domestic lighting were so satisfactory that the dynamo house was soon filled with machinery, and, as the demand still rapidly increased, an additional and much larger site was obtained in St. Philip's Marsh and a new generating station built and equipped last year. The total capital outlay on land, buildings, plant, etc., to March 25th last was about 385,000*l.*; but a considerable extension of street lighting in the suburbs is to be carried out forthwith, and the Electrical Committee already find their new premises inadequate. The writer does not propose to go into any details of the electric lighting, as the electrical engineer, Mr. H. Faraday Proctor, has kindly consented to read a paper on the subject, and those Members of this Association desiring to do so are invited to inspect the works.

Hospitals.

Until the year 1892 the hospital accommodation for diseases of an infectious character was totally inadequate and of the rudest character, but in that year the Council purchased a site

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of thirteen acres at the extreme southern end, about 2½ miles from the centre of the city, at Novers Hill, intending to use it for both fever and small-pox patients, but the Local Government Board at once refused their sanction to small-pox being treated with other diseases simultaneously on the same site. It was therefore decided to use the Novers site for small-pox, and the Ham Green estate having come into the possession of the city in 1894, it was resolved to devote about 38 acres of it to the purposes of a fever hospital.

The arrangements on the two sites having been fully described in reports issued in 1899 and copied, with illustrations, into the public journals, cannot now be the subject of a paper under the rules of this Association, but the writer will simply state the accommodation at present provided at each place.

At Novers Hill, a permanent administration building provides accommodation for a resident medical officer and a matron, with twelve bedrooms for nurses and servants; a permanent isolation block for eight beds and a laundry have been built, and 53 beds are provided in temporary wooden buildings constructed in a few weeks during the prevalence of small-pox in 1893–94.

The Ham Green estate is situated about 3 miles from Clifton, on the left bank of the river Avon; the mansion and about 38 acres of land being assigned for hospital purposes. The mansion has been re-arranged as the administration building, and has accommodation for a resident medical officer, a matron, nurses and servants. Four ward pavilions have been built, of red brick with freestone dressings, each containing seventeen beds, and an observation ward having eight beds, all providing a cubic space of over 2000 cubic feet per head. In addition, a capacious laundry and disinfecting buildings have been constructed, and the whole establishment is lighted by electricity generated on the site. Stabling has been provided for eight horses; an extensive kitchen garden provides the establishment with vegetables as well as growing bedding plants for the public parks. The sewage is treated in precipitation tanks of the Dortmund type before the effluent is discharged into the river.

The number of beds at the two hospitals at the disposal of the Medical Officer of Health is 129, and this has been found inadequate for a population of nearly 335,000; therefore the

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Council resolved to increase the number of beds at Ham Green by 58, by the construction of a second observation block and of a pavilion having wards on the ground and first floors, whereas those already built have the wards on one floor only. The Local Government Board has sanctioned this mode of extension after much negotiation and the submission of many plans. The increase in the number of beds for patients will require a corresponding increase in the number of nurses and servants, and extra provision will be made for them by extending a wing from the back of the administration building. A high-level water tower will also be put up to ensure a constant supply of water at high pressure. The cost of the works already executed and of those contemplated will amount to about 97,000*l.*

As the extensions have not hitherto been described, and are not of the usual type, the writer has desired his architectural assistant, Mr. Harding, to prepare a short paper, illustrated by plans approved by the Local Government Board, for the consideration of the Members of this Association.

Houses for the Working Classes.

A consequence of some of the numerous street improvements effected during recent years has been the demolition of a number of small houses occupied by persons of the labouring class; and one of the conditions precedent to the Local Government Board granting authority to raise the cost of the street improvement by means of a loan was the construction at suitable places of dwellings to, nominally, house those persons who had been dispossessed. The word "nominally" is used advisedly, for, long before the new dwellings could be built, the original occupants of the demolished cottages had become absorbed in the surrounding population, and the Corporation dwellings are readily rented by a superior class of artisan. After numerous plans had been prepared, and rejected on the score of cost by the Committee, and as not being sufficiently palatial by the Local Government Board, a mean was struck to which the Board assented. The principle had been previously tried in Birmingham, and consisted in constructing the dwellings in blocks: those on the ground floor being quite separate from those on the first floor, the latter being approached from the street by a flight of stone steps leading to balconies

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giving access to the doors of the houses. The houses have in some cases three rooms and in others two rooms, but each is complete in itself. Some of the blocks front a public street with an open space at the back common to all the inhabitants, while others are built fronting a street laid out at right-angles to the public thoroughfare. The accommodation in a three-roomed house calculated to shelter five persons consists of a living-room 14 feet by 14 feet, one bedroom 14 feet by 8 feet, and one bedroom 12 feet by 9 feet, wash-house, w.c., sink and coal-bunker; these are let at 4*s.* 6*d.* per week. The two-roomed houses, calculated to accommodate three persons, have a living room 14 feet by 14 feet, and one bedroom 12 feet by 9 feet, with offices similar to those provided for the larger houses; these let at 3*s.* 3*d.* per week. Four blocks have already been built containing an aggregate of thirty-eight 3-roomed houses, and twenty-two 2-roomed, sufficient to house 256 persons. A fifth block is in process of construction of six larger and four smaller houses to accommodate forty-two persons. When completed, the total number of persons that can be accommodated in the five blocks will be 298. The land on which the blocks are built was the property of the Corporation, and the cost of construction, including roads and sewers, will amount to about 14,000*l.* The total weekly rents, if all the dwellings were occupied, would bring in 734*l.* 10*s.* per annum, from which must be deducted rates and water. The blocks have been plainly built of sound red bricks, with window sills, window and door heads, steps, etc., of artificial stone made from Portland cement and destructor clinker. The floors are made of cement concrete, and woodwork has been reduced to a minimum.

Museum and Libraries.

The museum and valuable reference library in Queen's Road have been acquired for the city through the liberality of a former occupant of the civic chair, and recently the adjoining land has been purchased, on which is commenced the construction of a municipal art gallery to be presented to the city by Sir W. H. Wills, Bart.

Handsome buildings have been erected at St. Philip's, St. George's, and Cheltenham Road, for free libraries and reading-rooms, and a small branch library opened at Stapleton, all fully equipped.

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Bristol is much behind many smaller towns in not being provided with adequate municipal buildings to accommodate the various departments, who now have their offices in buildings scattered over different parts of the city, a system resulting in much inconvenience and loss of time. Since the increase in the number of the members of the Corporation in 1897 a new council chamber has been constructed at the back of the old offices in Corn Street, and a rates-receiving office and others, built in connection with it.

Highways and Cleansing.

Since 1892 the Sanitary Committee has carried out by day labour the works connected with highways and sewers, cleansing and watering the streets, and removal of house refuse. To enable these duties to be efficiently performed, depôts were established at various places; the most important being that in St. Philip's Marsh, about 6 acres in extent, where is situate the refuse-destructor, stabling for 120 horses, with equine hospitals for accidents and infectious diseases, cart-sheds, workshops for making new and repairing old carts and wagons, engineering and carpentering shops, and an extensive factory for making artificial flagging.

This depot was fully described by the writer in 1896, on the occasion of a district meeting of this Association, and as the paper was published and illustrated in Vol. XXIII. of our Transactions, it is not necessary to do more than refer to it.

Refuse Destructor.

A 16-cell destructor, built back to back, of Fryer's type, was completed in 1892. The foundations below the ground-level cost 2909*l.*; destructor, cremator, office and approach road 6820*l.*; chimney 1689*l.*; total, 11, 418*l.*

	Tons.
The destructor incinerates per week about	650
or, during the day of 24 hours	108
Average amount burnt in each cell per day	6¾
The eight cells on one side fitted with steam blast burn per week	433
Each cell burns per day of 24 hours	9
The eight other cells fitted with rocking bars, burn per week	217
Each cell burns per day of 24 hours	4½

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The front cells are charged every two hours. The back cells are charged every four hours. Amount of refuse per charge averages about 15 cwt.

The destructor is worked by eighteen firemen, divided into three gangs of six men, each man working eight hours per turn and charging eight fires in the turn.

The temperature in the main flue averages about 1100° F., a portion of the waste heat being utilised by passing it through a tubular boiler 12 feet by 8 feet, which raises steam for driving two mortar mills and one stone crusher, and supplying steam for the forced draught.

The residue averages 35 per cent., and during the year ended March 25, 1902, was disposed of in the following manner :—

Material.	Sold to the Public.		Used by Corporation Workmen. Quantity in Tons.	Carted to Tips. Quantity in Tons.
	Price per Ton.	Quantity in Tons.		
	s. d.			
Mortar manufactured from clinker and lime	7 6	14	1777	..
Screened ashes	1 8	2635	28	..
Rough ashes	1 0	343	..	..
Breeze	1 3	170	143	..
Clinkers for road foundation ..	1 0	849	1324	2239
Clinkers for concrete flagging and artificial stone dressings	..	..	1029	..
Flue soot	9 0	1	..	80

Artificial Stone Plant.

Concrete slabs for footways are made by three methods, viz. hydraulic pressing plant, rocking machine, and hand labour in wooden moulds. Window and door heads and sills, steps and other artificial stone dressings are made by hand labour in wooden moulds.

Hydraulic Press.—This plant was supplied by Messrs. C. and A. Musker, of Liverpool, and consists of two rams, one forcing the filled mould under the top bed, and the other applying the pressure. The mould is then withdrawn from under the top

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bed, turned over, the slab dropped on to a trolley and run out to the drying shed.

The pressure on each paving slab is 2 tons per square inch.

The area of slabs made in one day of 9½ hours is 97 superficial yards, and the cost of production 2*s.* 6*d.* per yard, inclusive of first cost, depreciation of, or repairs to the machine.

Rocking Machines.—These are the invention of the Works Superintendent, Mr. W. H. Baker, and consist of an iron perforated mould, mounted on a cam shaft; by turning the shaft a rocking motion is given; this allows of the surplus water filtering through the perforations, secures a homogeneous mixture and a thorough consolidation of the materials.

The area of slabs made by one machine in a day of 9½ hours is 30 superficial yards, and the cost of production 2*s.* 1*d.* per yard.

Hand Labour.—Slabs and building dressings are made in wooden moulds by hand, the cost of production being 2*s.* 4*d.* per superficial yard for slabs, and 2*s.* 8*d.* per cubic foot for dressings.

WORKSHOPS.

The following is a statement of the principal work executed during the year ended March 25, 1902:

Number of carts built complete	5
„ cart bodies built	8
„ barrows built	21
„ hand-carts built	2
„ water-barrel hand-carts	2
„ sundry new articles	303
„ repairs to carts	944
„ „ wheelscrapers	18
„ „ wheelbarrows	92
„ „ hand-carts	18
Sundry repairs	494
Number of nosebags made	73
„ collars made	14
„ tarpaulins made	68
„ loin cloths	36
„ capes made	7
„ sundry new articles	204
„ repairs to harness	1256
„ „ loin cloths	172
„ „ tarpaulins	78
„ „ nosebags	43

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Sundry repairs	103
Number of horse-shoes fixed	8600
Sundry repairs and extras to horse-shoes	1939

STABLES.

Number of horses	216
Stabling at Albert road for	120
Stabling at Clement Street for	90
Hospital stable	20

Each horse worked on an average 312 days during the year ended March 25, 1902, and hauled per day an average of 8·75 loads, excluding ashes removal.

The cost per horse per week for provender and bedding was 14*s.* 1*d.*

The cost per horse and cart per day, including driver's wages, depreciation, repayment on loans for stables and establishment charges, is 8*s.* 6·13*d.*

CEMETERIES.

Finally, the Corporation makes decent provision for deceased members of the community in two extensive and well-managed cemeteries.

GENERAL.

Although the municipality has not been idle during the last quarter of a century, yet the important undertakings of gas making and distribution, water supply and tramways still remain in the hands of public companies. The gas company, unaffected by the competition of electric light, still pays handsome dividends, the water company provides a constant supply, unsurpassed in any town in England, while the tramway company was one of the first to adopt electric traction, and now serves every district of the city with a quick, regular service in large well-appointed cars. The pluck and enterprise which have started and carried on successfully these great undertakings is to be admired; but it is a matter for regret that the financial advantages are not retained for the benefit of the citizens, but go to enrich numberless others whose only connection with the town is to receive their dividends from the commercial undertakings carried on in it.

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DISCUSSION.

Mr. E. G. MAWBEY: I have pleasure in moving a very hearty vote of thanks to our President for the preparation of this excellent paper. He has referred in the paper to the various companies working in Bristol, the Water and the Tramway Company. I am quite sure that we shall reap considerable advantage by spending some of our time in seeing what these companies have done, and particularly the Tramway Company in the matter of electric traction. I know the company have a very admirable power-station and other things worthy of our inspection.

Mr. J. DEANE: I have pleasure in seconding the vote of thanks. May I ask one question with reference to the provision of artisans' dwellings? You state that only two bedrooms are provided in one class of houses, and a single bedroom in the other. I should like to know if that limited bedroom accommodation has proved satisfactory in the houses already provided.

The PRESIDENT: Yes. A certain number of persons were displaced and the provision made meets with the approval of the Local Government Board.

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NOTES ON THE WEAR AND MAINTENANCE OF TRAMWAYS.

By C. F. WIKE, M. Inst. C.E., City Surveyor, Sheffield.

During recent years the attention of Municipal Engineers has been very much occupied with the question of tramways, and particularly those worked by electricity. As this form of traction has only lately been adopted in this country to any great extent, most of the information published has dealt more with the question of construction than with that of maintenance and it has occurred to the Author that statistics and information as to the wear of electric tramways would be of interest to Members of the Association.

For some time observations have been made of the wear of the permanent-way of the Sheffield tramways, and the broad results are given in this paper, together with a few explanatory notes.

General Statistics.—The general statistics as to the Sheffield tramways are as follows. The total length of tramways authorised is 89 miles of single-track, of which, up to March 25th last, 50 miles had been constructed. The population is 409,000. The number of cars in use is about 160, of which about a third are single-deckers. The weight of the double-decked cars is approximately 8½ tons, and of the single-decked cars 8 tons. The worst gradient is about 1 in 9·5, and the sharpest curve (except in depôts) has a radius of 40 feet.

Wear of Rails.—It may first be advisable to state briefly the Sheffield specification for rails. They are of girder type, 7½ inches wide on the flange, and 7 inches deep. The weight is 108 lbs. to the yard, and the analysis is as follows:—

> The quantity of carbon must not be less than 0·35 per cent., or more than 0·45 per cent.; and of manganese, not less than 0·70 per cent., or more than 1·10 per cent. The

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quantity of silicon must not be more than 0·1 per cent.; sulphur, 0·08 per cent.; arsenic, 0·08 per cent.; phosphorus, 0·08 per cent.; copper, 0·08 per cent.; and there must be no other material present, except iron.

The following are the mechanical tests:—

A piece of rail 8 to 9 feet in length is supported on iron bearings 3 feet apart, and a cast-iron monkey weighing 1000 lbs. is allowed to fall freely upon the centre of the rail first from a height of 10 feet, and at this blow the deflection must not exceed 1 inch.

The second blow is from a height of 15 feet, and the deflection must not exceed 2½ inches.

The third blow is from a height of 20 feet under the same falling weight conditions, and the rail must not show any sign of fracture after the three blows.

The tensile test-piece must be machined from the head of the rail; the area for testing must be ½ square inch, and the length for elongation 2 inches.

The tensile stress must be from 37 to 45 tons per square inch, with a contraction of sectional area of not less than 20 per cent.

Up to the present the rails have been rolled in 30-feet lengths, but the most recent order provides for a length of 45 feet. The width of tread is $1\frac{1}{16}$ inches, and the depth of groove is $\frac{5}{16}$ inch. There is a clearance of $\frac{7}{16}$ inch between the lowest point of the wheel-flange and the bottom of the groove (see diagram A), and it is considered that when the rails have worn sufficiently to enable the flange to touch the bottom of the groove their life will be at an end. Before this can happen a sectional area of 0·706 inch of steel must be worn away.

Observations have from time to time been taken to ascertain the rate of wear upon the rails, and the results are given in the table opposite. These are interesting as showing how much more the wear is regulated by the gradient than by the number of journeys, the reason for this being that the action of the brakes is far more destructive than the uphill traction.

The figures given in the table are further illustrated by the drawings on diagram B.

Rail Joints.—Diagram C illustrates the rail joint adopted. The fish-plates are 3 feet long, and 8 nuts and bolts are used to each joint. The weight of the fish-plates is 80 lbs. per pair, and

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—	Gradient.	Months Wear.	Number of Journeys.	Reduction of depth of groove.	Percentage of total possible reduction of sectional area of tread of rail.
				inch.	
A. down track	1 in 15	34	764,200	0·25	54·1
A. up "				0·09	15·1
B. down "	1 „ 23	34	865,507	0·15	30·6
B. up "				0·09	15·1
C. down "	1 „ 26	34	593,704	0·14	26·4
C. up "				0·06	8
D. down "	1 „ 33	34	764,200	0·125	22·1
D. up "				0·07	11·6
E. down "	1 „ 38	34	593,704	0·125	22·1
E. up "				0·06	8
F. down "	1 „ 787	34	593,704	0·125	20
F. up "				0·06	8
G. single line	1 „ 10	34	395,656	0·10	18·7
H. down track	1 „ 21	34	196,696	0·09	15·1
H. up "				0·03	3·9
I. down "	1 „ 15	34	271,803	0·09	15·1
I. up "				0·03	3·9
J. down "	1 „ 160	34	579,979	0·09	15
J. up "				0·06	8
K. down "	1 „ 268	19	254,412	0·07	11·6
K. up "				0·035	5
L. down "	1 „ 15	34	166,734	0·07	11·6
L. up "				0·03	3·9
M. down "	1 „ 24	34	197,828	0·07	11·6
M. up "				0·03	3·9
N. down "	1 „ 84	30	65,384	0·06	8
N. up "				0·06	8
O. down "	1 „ 79	26	172,558	0·06	8
O. up "				0·028	3
P. down "	1 „ 17	30	65,384	0·06	8
P. up "				0·025	2·9

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the specification is the same as for rails. Lock-nuts have been used. A space of $\frac{1}{16}$ inch is left between the rail ends to allow for expansion.

Some of the older and most used lines have already been taken up for the purpose of laying additional crossovers or doubling the track; and it is satisfactory to know that in scarcely any case has the joint been found defective. It will be noted that no sole-plate is used, and the Author would be glad to know the experience of other tramway engineers as to the advantage or otherwise of this addition to a rail joint.

Bonding.—The bonding used is the "Chicago" type. Two bonds are provided to every rail joint, and the tracks are cross-bonded at distances of 40 yards. Up to the present no trouble has been experienced from loosening or other defects of the bonds.

Points and Crossings.—So far as permanent way is concerned, this appears to be one of the matters most in need of improvement. Several types have been put down in Sheffield, mostly of British make, but as an experiment some American points have also been tried. In these a special metal is introduced for the parts subject to the greatest wear.

It is more difficult to give data as to the wear of points and crossings, than as to the wear of rails, because the conditions under which the points are used vary in nearly every case.

A further diagram D is however given, showing the amount of wear on some points and crossings of different types in Sheffield, with figures as to the number of car journeys, gradients, etc.

One particular junction is perhaps worth special notice, and, to explain the Author's meaning more fully, a plan of this (diagram E) is appended.

When the tramways were first constructed this junction was not laid quite as at present (some of the points now having been omitted), and the materials used were the ordinary rails, points and crossings. The inner rail on the main line had a curve of 54 feet radius, and the difficulties were greatly accentuated by the fact that the junctions were on a curve, and also because, on account of the gradients of the converging streets (some of which could not be altered) it was impracticable to get the usual super-elevation on the outer rails.

As the circumstances were exceptional, perhaps it is scarcely necessary to go into details as to the number of car journeys over this junction, but after a period of twenty-five months it

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was considered advisable to relay it. The curves were altered so as to give a minimum radius of 60 feet; the position of the points was somewhat modified; their number was reduced; and the whole of the work was carried out both as to the rails, points and crossings in manganese steel, the patterns and castings being made specially for this purpose. The work was a very expensive one, costing about 1500*l.*, but the junction has since worked satisfactorily. As it has only been in use a few months since relaying, however, perhaps it is too early to express a definite opinion as to the ultimate result.

The case is one almost by itself on account of the curves, gradients, position of points, tramway and other traffic, etc., and the Author thought it worth while to mention the difficulties experienced and the nature of the remedy adopted.

Paving.—Various forms of pavement have been laid, including granite, wood and gritstone setts, a Scotch basalt or whinstone, and also tar macadam with a single row of setts adjoining each rail.

Several miles of the latter paving were laid, largely as an experiment, and the experience has been such that a repetition is improbable; in fact, a long length of track on one of the main suburban roads—which, it may be mentioned, was seen in course of construction by the Association in June 1899—has worn so rapidly that it is now proposed to replace the tar macadam track with setts.

Records have been kept of the cost of maintenance and renewals, and these have been reduced to an average cost per mile per year for each type of paving. New work not necessitated by wear and tear, has been excluded from the totals, and two routes to which special circumstances apply have been omitted. One of these, a tar macadam road, is maintained by contract —also as an experiment—and the other is subject to conditions which are not likely to obtain in another case.

The figures—which are only presented as approximate—are:—

Nature of Paving.	Average Cost of Maintenance (not renewal) per Mile per Annum, Single track.		
	£	s.	d.
Granite paving	19	13	6
Granite paved tracks, macadam sides	47	9	6
Gritstone	49	11	0
Wood paving	54	8	3
Tar macadam: hit-and-miss setts against rails	64	13	3

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The foregoing information is not put forward as a complete and exhaustive survey of the subject. The conditions must vary in different towns; and the Author hopes other Municipal Engineers will also give their experience.

The subject is becoming an important one, as the question of allowance for depreciation, etc., is constantly arising, and it would no doubt be to the advantage not only of Engineers, but also of municipalities who own tramways, if reliable data as to wear and tear were available. It would also be useful to have expressions of opinion as to the chemical analysis of the rails, the lengths of rails, and type of joint.

At present, nearly every specification differs in one point or other, and the Engineering Standards Committee is now dealing with the question of tram rails and their accessories, in the hope of securing some degree of uniformity.

The object of this paper is not only to give information, but also to elicit the views of other Engineers upon a subject which is daily becoming more important, and it is hoped that opinions upon the points raised may be freely expressed.

DISCUSSION.

The PRESIDENT: I am not at all surprised to hear that a paving of tar macadam with a single row of setts adjoining each rail has not proved a success. The cost of maintenance per mile per annum is put down as 54*l.* 8*s.* 3*d.* for wood as against 19*l.* 13*s.* 6*d.* for granite paving. Of course, where streets are paved with wood it is essential that wood paving should be used for the track. For the credit of Bristol, I may say it was the town which fought that question and carried it from court to court until a decision was given in favour of the corporation. The effect of the decision is that when a local authority desires to make any alteration in the material with which the street is paved, the Tramway Company are obliged to follow suit, the authority, in the first instance, being at the cost of laying the material, but the Tramway Company afterwards having to maintain whatever material the authority like to lay down. The Corporation of Bristol succeeded in that contention after a long fight, and it was a very great win to the advantage of other towns.

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DIAGRAM A

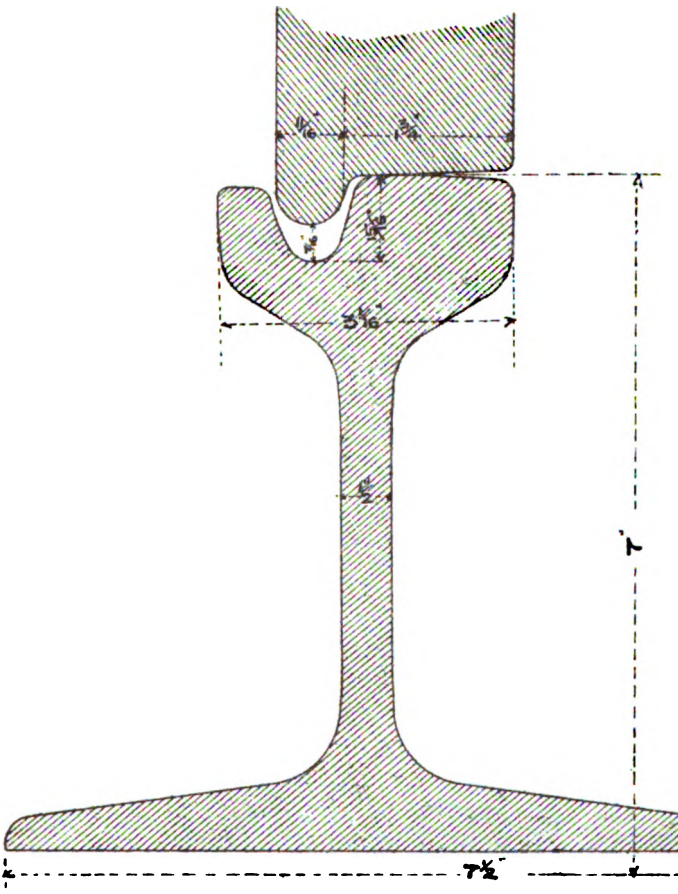

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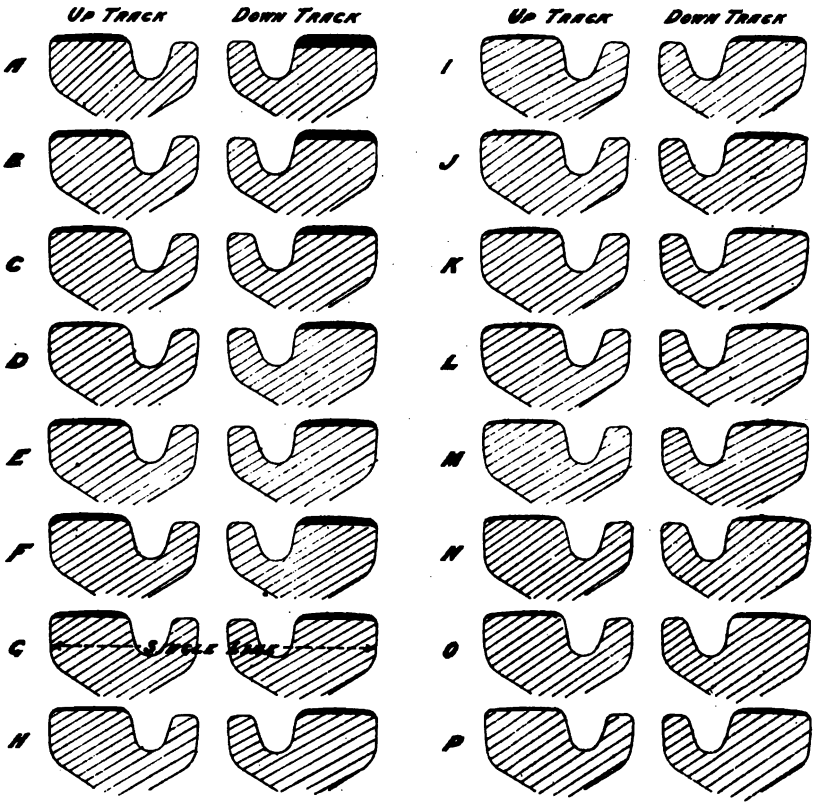
DIAGRAM B.



SCALE OF INCHES.

1 2 3 4 5 6 7

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DIAGRAM C

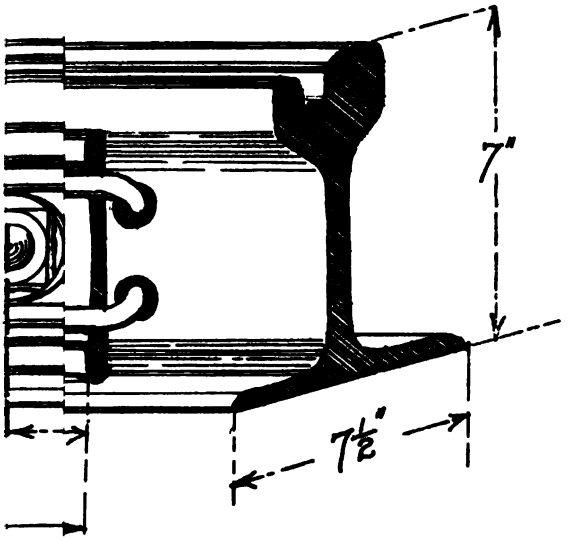

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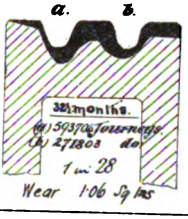
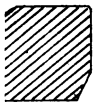
DIAGRAM D





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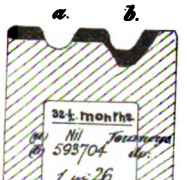

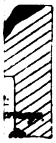

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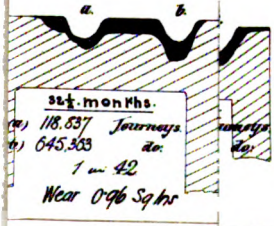

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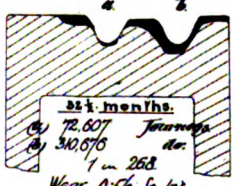

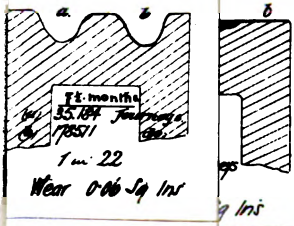

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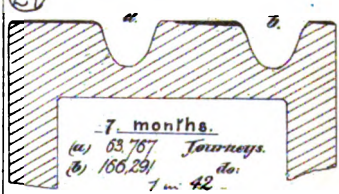

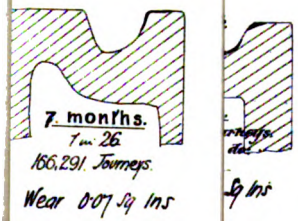

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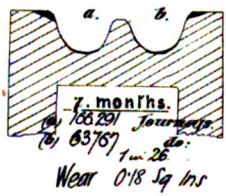

30 Inclusive are Special Castings

Charles F. Wike
City Surveyor
Sheffield

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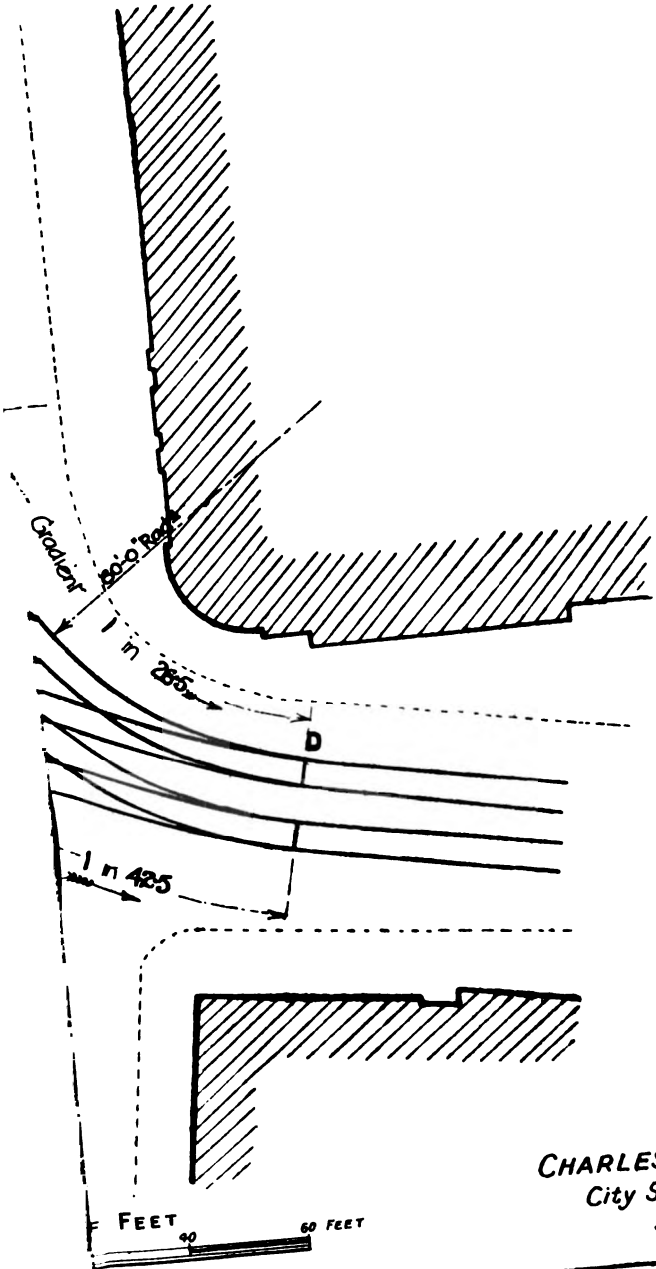

CHARLES F. WIKE
City Surveyor
SHEFFIELD.

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Mr. J. PATON: I think this paper of Mr. Wike's is exceedingly useful, but I doubt if he has been able to make it quite as complete as it should be made. One great objection that the private companies have to the municipalisation of tramways is that corporations do not provide an adequate depreciation fund in addition to the payment of interest and sinking fund. Of course, that is a question of policy more for the consideration of corporations than of ourselves as engineers. We all know in the case of a corporation they must keep up the lines in an efficient condition; but it is a question of how much depreciation should be put aside in connection with the renewal of the line. Electric traction in this country is comparatively new, and I doubt very much if, in any towns where electric traction has been in operation, sufficient experience has been obtained to guide local authorities as to the exact amount to be put aside. I know in regard to the lines in Plymouth, which have been electrically equipped for over four years, that the rails are now showing rapid signs of wear, and that occurs more particularly on sharp curves and steep gradients. Of course the wear will depend very much upon the traffic. Those are questions of the greatest importance to corporations who are working tramways, and it is my opinion that some sum should be placed to a fund—whether called depreciation or renewal being a matter of indifference. You all know the system of equating loans is a vicious one. You get equated in one loan works of unequal life. The paving will last, perhaps, fifteen years, the rails ten years. How are you to provide for the renewal of the rails at the end of that period? It must come out of revenue unless you provide some fund for renewal. If Mr. Wike could give some estimate as to the life of the track it would be very useful information and a guide to other engineers in other towns.

Mr. J. A. BRODIE: With regard to the hardness of rails, I think the experience of tramway engineers generally in this country and abroad is, that 0·35 per cent. of carbon is rather too low a limit and that it would be wise to raise the percentage of carbon as much as possible. In Liverpool we got an average of 0·45 per cent. and in some cases as much as 0·55 per cent. The length of rails is the next point which calls for remark. In Sheffield, Mr. Wike states, they have used 30-feet and are now using 45-feet lengths of rail. A reduction in the number of joints is a matter of great importance, and in Liverpool we have

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used 60-feet rails generally. In the matter of joints, we have tried the ordinary butt joint with a substantial fish-plate; the "Dick Kerr" joint, the fish-plate of which comes through the under flange of the rail; the "Cooper and Howard-Smith" joint; and one or two others. Mr. Wike asks for the experience of other Members with respect to joints, and says he is perfectly satisfied with the ordinary joint with a pair of fish-plates. Experience seems to show that, with the ordinary joint with double fish-plates, where the fish-plates are a perfect fit, the whole of the work carried out in the best form and the packing under the rail thoroughly done with the best materials, little trouble need be anticipated. In Liverpool we have had such joints in use for nearly four years, and they are to my mind perfectly satisfactory. We have also the "Dick Kerr" and the "Cooper and Howard-Smith" joints, which are giving very good results, and in my opinion both are an improvement on the ordinary joint. I have also used the cast weld joints, and though troublesome to make, I find them very satisfactory when properly made. From my experience, I would recommend engineers not to consider the question of first cost only, but to use the best mechanical joint available. Personally I believe we shall ultimately come to one or other of the welded joints, when the manufacturers are prepared to make a thoroughly good job at a reasonable price. With respect to the wear of the rails, the average taken from the printe dtable of wear due to traffic appears to be somewhat greater than I should have expected and somewhat greater than, taken on the whole, we have had in Liverpool. We have in several cases a life of rail equal to the maximum deducible from the table, and we hope to get a number of years additional life out of the rail yet. That is in a part of the city where there are a large number of cars running, probably averaging two or three a minute over eighteen hours per day. On the average wear taken from the table it appears that we may expect a life of 2,500,000 vehicles passing over the rail, and it is a figure which put in that way may be useful. I am inclined to think that, while that is not an excessive view to take of the wear of the rail itself, we shall probably have to deal with the life of the rail from the point of view of the life of the joint, and it may be that figure may fairly represent the life of the tramway but would not fairly represent the life of the rail apart from the joint. In connection with the special work in Liverpool, we

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have tried a number of different types, and find that in this work again, it pays to put in absolutely the best work apart from the question of first cost on those portions of the intersections and work of that description which are subject to intensely heavy wear, whilst we have found the ordinary built up intersection is quite suitable for the more moderate traffic. I have no figures at the moment to compare with the figures given as the upkeep of the different kinds of pavement, but my experience shows that where you have a paving of a less depth than the rail so that the bottom web of the rail is thoroughly imbedded in the concrete, a less cost of maintenance may be expected than where the set or paving is the same depth as the rail.

Mr. E. G. MAWBEY: There is one point Mr. Brodie has raised of the first importance, e.g. that the life of the line will be practically determined by the life of the joint. I have come to the conclusion that we must devise something better than the ordinary joint with fish-plates. Suppose we take the Cooper and Howard-Smith joint. There seems to be a great difference of opinion as to how that joint should be made. It is a question whether the joint should be riveted or bolted. I know one Member who says, "I should not think of riveting the joints. If you have to replace the work you have to cut out the rivets." The answer to that is, if you have a bolted joint in two years you would have to cut that out. Another point, I believe, is that a riveted joint has an advantage in the bonding. I was very glad to hear Mr. Brodie say it was a great advantage to have some concrete over the flange of the rail. Where people go in for a rail laid flat on the concrete, the web of the rail gets loose, and there is that hydraulic action going on which loosens the paving all along the line. One other matter is the chemical composition of the rails. Well, I think Mr. Brodie is quite right, that these rails with 0·35 per cent. of carbon indicates a soft metal. On the other hand, the supporters of a soft metal say, "It is quite true that if you have a higher percentage of carbon you get a longer life of the rail, but there is an immense difficulty in the bending. You have a great number of the rails break in that way." I think we should try and specify for a higher percentage of carbon in the steel for our rails. It is rather disappointing to hear that English manufacturers have not yet been able to reach the standard of American work. I have always held that the English manufacturers are to blame for this and

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that they will have to suffer. But they have made great strides of late, and I am prepared to support English manufacturers as far as I reasonably can. As to the welded joint, some gentlemen claim immense benefits from this joint. There is no doubt the most perfect joint is one which is an absolute continuation of the metal, but you have great trouble in getting it. There is one other point in connection with this question, though it does not rise out of Mr. Wike's paper. I have the honour of being a member of the Committee of the International Tramway Congress, and the question of guard wires has been raised. We have been asked at Leicester to protest against the new regulations of the Postmaster-General which the Board of Trade are now supporting. Many tramway promoters are resisting this provision, but I do not think they have made much headway. We have tried in Leicester to get the telephone company to put all their wires underground, and we are also trying to get the telegraph wires placed underground. Still there will be parts of the town where we shall fail to do this, and if any gentleman has had any experience with these guard wires I shall be pleased to hear what it is.

Mr. A. E. COLLINS: We have 19 miles of track in Norwich, made with cast weld joints, and they are giving very good results. The company which did the work in Norwich recently had some junction work to do, and I noticed from this they abandoned the cast weld joint. There are difficulties with the cast weld joint, particularly at junctions, because you cannot avoid expansion owing to the great heat required in welding the joint. The New General Traction Company now appear to be using the Howard-Smith joint at all junctions. I must say that I do not admire the rail Mr. Wike has adopted. It does not appear to me to give the best chance to the fish-plate. I am very surprised to hear that any town should attempt to lay tar macadam on a tramway track with a single row of setts adjoining the rail.

Mr. F. S. YATES: The Author asks for the experience of tramway engineers with respect to the use of sole-plates, and I did hope that some of the previous speakers in the discussion would have taken up and dealt with this request for information. My opinion is that sole-plates are not necessary. The joints are the weak points in tramway permanent way, and my experience is that sole-plates weaken the weak point. They are difficult to fix because the rails have either to be lifted while the sole-plate

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is bolted up or space must be left under the rail in the concrete for the bolts to be inserted and tightened, and after that is done there is a difficulty in obtaining the same true bed under the joint as under other portions of the rails.

Mr. A. E. WHITE: It is my opinion that sole-plates are of considerable assistance to the joint, though I do not look upon them as of the same importance as a pair of fish-plates. It depends largely upon how the rail is laid as to whether trouble is caused by disturbing the rails in fixing the sole-plate. In my opinion the proper way to lay tramway rails is to pack them up in position and to fill in the concrete underneath, and if the work is done in this way the trouble mentioned does not arise. I know objections have been raised against laying in this way, but these objections I have never found to be of any weight in my own experience. With reference to the section of the fish-plate and the rail, I quite agree with Mr. Collins that you require a rail which will allow of a fish-plate with a fairly square shoulder both top and bottom, and with the angle at the top of the fish-plate the same as at the bottom, so that it will give a proper support at the head of the rail. There are two or three other points raised in the paper upon which Mr. Wike asks for an expression of opinion. One is with regard to the percentage of carbon in the steel. I quite agree with the Members who have already spoken that the percentage given by Mr. Wike may be increased. In my first specification I specified from ·40 to ·50 per cent. and at that time I think this was as high as English manufacturers would work to. In a more recent specification I have gone a little higher and made the carbon from ·45 to ·55 per cent. With reference to the form of rail joint, I think it will be found on most systems as Mr. Brodie has suggested, that the life of the rail will depend upon the life of the joint. The rail used in Hull is different to that adopted in most towns. It is a centre groove rail with a double tread and the joints are cut to splay to an angle of 45°. This rail, in my opinion, gives a very great advantage in the construction of the rail joint, as the wheel has always a solid rail under it either on one side of the flange or the other. I, of course, know that in most towns the adoption of a centre groove rail is out of question because they are already committed to a single tread rail. The paper is a very valuable one and gives some very useful information as to the wear which has taken place on the rails in Sheffield. The wear

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given on the down grade is considerably more than I should have expected it to be as compared with the wear on the up grade. It rather causes me to congratulate myself upon having to deal with a town where gradients are almost non-existent. I should like to ask whether the greater wear on the down grade is due to the slipper brakes, or what is the cause; whether the wear is the average over the whole of the rail and whether there has been appreciably greater wear on the joints than on the ordinary rail between the joints. With reference to the use of welded joints, I may say that before we commenced construction in Hull I made considerable inquiries with a view to adopting cast weld joints, and I abandoned the idea mainly in consequence of the inconvenience of cast welding the joints in the street. Another point which occurred to me respecting cast welding was that possibly the character of the steel at the joint might be changed by the heating of the rail caused in cast welding. This objection might also apply to electric welding.

Mr. J. A. BRODIE: In reply to Mr. Mawbey's question as to trouble with expansion and contraction in connection with weld joints, we found, with cast welding carried out in the summer time, that a distinct proportion of the joints pulled or broke when it came to the very cold weather we had in February this year; but that I do not look upon as a serious matter: the joints have not closed up again in the summer and from that I judge that the rails were heated rather too much in the laying, and if I were doing more I should be inclined not to continue the welding of the joints all through, but to leave a certain number of joints out, say weld three and leave the fourth until the three had regained their normal temperature, and then go back and weld the fourth joint. I am rather surprised to find on a gradient of 1 in 787, which for tramway purposes is practically level, that the wear on the downhill line should be double the wear on the uphill line. That also holds good with a gradient of 1 in 268. In those cases there must, I think, be some other reason than that of the gradient for getting double the wear. On the question of depreciation, I may say that in Liverpool we have decided to deal with the matter of maintenance very differently—that is to say, maintenance will not be skimped in any form. We put in everything that is done including special work, point crossings, curves and some slight alterations to lines every year as maintenance, and we are

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putting by for our system a minimum of 30,000*l.* a year or about 300*l.* per mile over and above full maintenance. I calculate that something like that will be required to maintain the line in perfectly satisfactory order over a term of 25 years.

The PRESIDENT: Mr. Mawbey has referred to the question of guard wires and the putting of telephone wires underground. In Bristol, the National Telephone Co. are putting all the telephone wires in conduits in accordance with an agreement made with them some four years ago. Not only have they put their wires underground but they pay to the corporation an annual contribution of 2*s.* for each subscriber for doing so. The wires are laid on the twin-wire system, instead of on the earth-return system. Formerly there was a constant buzzing which was extremely unpleasant and the subscribers occasionally heard scraps of conversation not intended for them, but now you can hear with great comfort.

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UNDERGROUND CONVENIENCES.

By J. RUSH DIXON, A.M.Inst.C.E., Engineer and Surveyor, Metropolitan Borough of Shoreditch.

In view of the prevailing tendency to provide more sanitary conveniences for the public of either sex, a paper embodying the notes and ideas of one who has had the opportunity of constructing five in a busy and progressive district of the Metropolis may interest some of the Members of this Association.

It will be generally admitted that these underground structures are a great sanitary acquisition and improvement over the older fashioned wood or cast-iron above-ground kiosks, which are more or less unbecoming, and are an obstruction in busy thoroughfares, besides having proved to be favourite resorts of pickpockets, when not under the immediate surveillance of an attendant.

The proportionate requirements of the female sex have been hardly recognised hitherto, as evidenced by their reluctance when provision was first made for them, but which has now given way to such appreciable usage that the women's sections are now almost as largely patronised as the portions arranged for men.

Site and Arrangement.

The sites chosen for these structures are naturally those where there is abundance of pedestrian traffic, and more often than not, the shape of the space alloted requires considerable ingenuity in planning, to get the most on it with a satisfactory arrangement of the sections.

Referring more particularly to conveniences in busy thoroughfares, the shape is generally either triangular with rounded corners, or oblong, and the latter may be regarded as the best: allowing as it does of a better placing of entrances, of straight staircases, and of a general squareness of arrangement below.

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Well arranged conveniences have also been built in the form of a full circle.

The shape of some conveniences is commented upon rather freely by those who do not know the difficulties one has to contend with, when instructed to provide a convenience of stated accommodation on a given site, but it is soon explained on looking into the circumstances.

As an instance of the difficulties so often in the way of ideal planning, the case of one convenience in Shoreditch may be quoted, where in scheming the arrangement of the triangular structure (Fig. 1) the Author was confronted on two sides close up by double tram lines which could not be diverted, and on the other side with close abutment on a large egg-shaped sewer, whose invert was very little below the floor level of the convenience. The roof of this convenience had also to form a suitable refuge in view of the place being recognised as a dangerous crossing. Such stricture on every side is not, however, usual, and by undercutting on one or more sides, the plan at floor level can often be very much improved.

Up to the present, conveniences have been arranged to include in the men's section :—urinals, water-closets, lavatories and dressing-rooms, with attendant's office and store rooms, the latter usually occupying the space under the stairs.

To the women's section a rather less area is allotted, but it also comprises urinettes, water-closets, lavatories and dressing rooms, with office and stores as before.

It is important that the placing of these should allow of easy and direct access, and that the doors open conveniently into a roomy space to avoid collisions or crowding together.

Constructional Notes.

It may be useful to remind you of the following general particulars of construction.

A concrete foundation at least 12 inches deep to be provided under footings of walls and over whole floor area, and a backing of concrete not less than 6 inches thick all round outer walls.

The main walls, 18 inches thick, built in cement with internal facing of glazed brick, and, for ornamentation, having a dado of different coloured bricks or of marble, and a suitable flat frieze or coloured courses of bricks under roof.

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The walls outside are lined both horizontally and vertically with a bituminous damp course.

All corners and angles of floors and walls should be rounded.

The roofing formed of pavement lights in small rectangular lenses in frames, any required circular or angle shapes being specially cast. The pavement light frames set into rebated stone or granite kerbing which is carried on girders divided up by cross joisting as necessary. The whole roof fixed to arranged falls for throwing off water.

As a guide in ordinary cases, the sizes used by the Author may be given as follows: Granite kerbing 8 inches by 6 inches; main steel girders 8 inches by 4 inches weighing 26 lbs. per foot; cross joisting 8 inches by 4 inches, weighing 19 lbs. per foot; beaded lenses 4 inches by 3 inches.

There should be no steps to compartments inside the convenience excepting to the attendant's office and lavatories, which usually have wood block floors, and are slightly raised above the general level. The rest of the flooring should be ornamentally tiled with borders.

All woodwork should be of teak, and be kept off floor level by means of stone or glazed brickwork shoes or blocks, so that the washing out with hose may not affect the woodwork.

Staircases.—The placing of the stairways is one of the most important features of a well-planned convenience, and has much to do with the attainment of proper ventilation of the interior.

Where possible, two staircases should be provided and used as entrance and exit, especially in the men's portion, where the urinal accommodation is so constantly patronised. Winding steps should be avoided where possible. The stairway to the women's portion should of course be placed in the least observed position. To avoid any crossing over carriageway, it is a good plan to have the stairways on the footways with subways leading from them under the carriageway to the convenience.

By constant use the stair treads soon become worn, and it is then advisable to fix some immovable and non-slipping patent coverings, which serve their purpose admirably. A sunk gutter with white glazed channel or gutter, covered at floor level by a movable grating, should be provided at the foot of stairs, to arrest the water which gathers on and runs down the purposely tilted steps.

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The railings guarding the stair spaces are usually of an ornamental character about 4 feet 6 inches high with the lower portion more closely arranged to act as a screen. To supplement this, and to prevent mud splashing on persons, it is also necessary to fix solid screens of enamelled iron or glass inside the more exposed portions of the railed-in space. A pleasing and effective screen is also procurable by an arrangement of shrubs in boxes placed near the entrances.

For locking up at night, gates are provided at the top and bottom of stairs. At the top they are hung to open and catch back on the side of the railing, and at the bottom they may take the form of a sliding door or collapsible iron framework of the Bostwick pattern, arranged to shut back into a recess formed in the brickwork. An ornamental grill can be fixed over gates at bottom if necessary to fill in space overhead.

Office.—The attendant's office should be placed so as to command a clear and uninterrupted view of the stairways, as well as of all the doors of compartments. In some conveniences one finds the attendant's office and lavatory are combined in one cubicle in the centre. This may be economy of space, but allows of too little privacy, and is a mistake, as is also the idea of having the attendant's office and store room in one, in what may seem an available space under a staircase, being as a rule too limited for the office and not the best position for supervision.

Water-Closets.—The w.c. compartments should be wide enough to admit of usage by stout persons and long enough to give room for doors to open inwards and leave sufficient space in front of seat. The divisions are usually of marble, about 1½ inches thick and 7 feet high, surmounted by a teak capping, but they could, of course, be of slate at less cost; whereas 4½ inch glazed brickwork partitions take up so much more room.

Urinals.—The urinals are set against walls in straight ranges, or can be full hexagon, half-hexagon or angle-shaped to suit required position. They should be so formed as to allow a person to stand well up into them without risk of splashing back on his legs or feet. Those generally favoured have circular glazed ware backs and bases in one piece with slate shaped treads, and with as few joints as possible. They empty into a gutter having a galvanized grating over. The front, jambs and tops may be of porcelain, stone-ware, slate or marble. They are flushed by a water-spray or sparge from the top falling all round and supplied

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from automatic syphon-action 10-gallon cisterns, which should have reverse-action regulating supply valve.

Urinettes.—Latterly some attention has been given to providing a specially formed fitting to be used for this purpose at a reduced charge in the women's section, instead of having to pay the full charge for use of w.c. At Shoreditch the provision seems to be greatly appreciated. The compartments are arranged as shown on Fig. 4, and have a spring waterproof curtain as a front screen.

Lavatories.—These are conveniently arranged with the required number of basins, generally in some approved "tip-up" form, set in a marble top, with sufficient elbow-room between each, and having soap and nail-brush trays, small shelf over, and large mirror. Hot and cold water supply to each basin, the hot water being supplied from a geyser heated by gas. It is better to have one large dressing-table with large mirror in front than smaller ones in different positions.

Fittings generally.—Of the multitude of special requisites and fittings supplied by well-known sanitary engineering firms, the Author need give no description in this paper, but to anyone interested, the excellent catalogues so readily presented are well worthy of perusal. Every detail has been well studied by these experts, and to entrust the complete work to some of them is to ensure the provision of a convenience in every way creditable to the authority for which it is constructed, and to the firm undertaking the job. The plumbing work in many conveniences in London is a fine object lesson to those seeking examples of perfect workmanship of that description.

Flat decorations should be used to the greatest possible extent in the nature of glazed coloured brick or tiled dadoes and friezes. Where possible, painting should be avoided, as it soon becomes badly affected by the damp and peculiarly destructive agents always present in the atmosphere of these places. For this reason, where it is possible, all girder work should be encased or tiled outside to prevent the inevitable unsightly rust-stained appearance and peeling off where painted iron or steel work is exposed. It is quite enough to have to be constantly repainting the underside of the framing of pavement lights, particularly as—so far as the Author is aware—no satisfactory cement has yet been introduced that will provide an impervious bedding for the frames of lights on the stone or granite kerbs

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into which they are set. Many compositions have been tried, but the unequal contraction is very noticeable when rain has to be kept out.

Drainage.—It seems hardly necessary in this paper to particularise on the drainage, as the opportunity is generally taken to make full use of such chance for a model system. It may, however be useful to remind you that it is advisable to collect all the lavatory wastes and surface gullies into one branch before coming into contact with the w.c. and urinal drains. It is no advantage to have many chambers, but there should be easy means of access through the drains to every fitting, and to avoid short branches to the main drain from the outgo of each w.c. pan, it answers well to place this drain in line directly under the pans. A convenient means of ventilating the chambers is by connection to the base of specially perforated guard-posts on the refuge overhead.

Where there may be possibility of sewer-flooding in case of storm, it is advisable to supplement the precautionary valve arrangements by having some automatic means of warning the attendants that a back-flow from sewer is taking place. In one of the Islington conveniences a warning bell is automatically set ringing during such emergency, and the attendant can immediately manipulate the stop flaps and avert danger, while the drainage is diverted into a large storage tank until the sewer can be depended upon in the ordinary way.

Storage Tanks for Water.—Capacious storage tanks under the roof or under the floor should also be provided where there may be any possibility of failure or even temporary stoppage of the regular water supply.

Lighting.

The necessity of having these places well lighted, makes it essential that all the available area of roof should be formed of prism lights and reflectors, seeing that all sunlight must come by such means, and has so, indirectly, to reach any portion that has been cut under the roadway. The staircases, too, must be thoroughly well lighted at all times. Electric light has proved the greatest boon as an additional means of lighting, but gas must, of course, be used as an alternative, and with incandescent burners a really capital effect is obtained; but there is some attendant heat and the fumes to contend with, and the prevailing

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difficulty of obtaining complete ventilation by natural means is thereby proportionately increased.

Ventilation.

In the Author's opinion, a perfectly ventilated convenience is something which has yet to be attained. Their position underground accounts principally for this, of course, and the condition is not assisted by the ever-varying humours of our climate. A humid outside atmosphere has such an effect inside many of the conveniences in London, that they become positively offensive, and no amount of swilling out with scented deodorants can keep down the bad smell.

The usual methods of inducing a constant current are by arranging for wall openings to be left where possible all round the interior just under the roof, which space is continued in the form of a grated duct to communicate with the surface above. Given a proper disposition of the stairways, this arrangement is about the best that has yet been devised.

Fair results are in some cases got by ventilating columns with large perforated bases being placed on the roof.

Automatic water-driven fans are also largely used, and these certainly displace the air surrounding them and assist in establishing a current. The water is further utilised by connection to flushing cisterns.

Administration.

On the outside above, the sections are easily made discernible by legible tablets fixed to the railings. Some prefer the plain words "Men only," or "Women only," instead of "Gentlemen only," or "Ladies only," as more frequently seen.

Inside, of course, the provision of plain clear names on the different compartments, and the placing of the scale of charges in a prominent position, is essential.

A speaking tube should connect the offices of the men and women attendants, so as to afford communication when necessary.

The cleaning and washing devolves on the attendants, and is mostly done by means of a hose attached to the tap which is provided in each portion, the hose being of sufficient length to reach every part of the interior, as well as up the staircases.

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There are different systems in vogue of collecting the fees: some favour the penny-in-the-slot lock-up doors, others use tickets and bell-punches, as in Shoreditch, where a special man is employed to generally supervise the attendants, and to make a periodical collection of the moneys taken.

The charges vary in different places. In the better class districts of the Metropolis they are usually, for use of w.c., 1*d.*; wash and brush up, 2*d.*; dressing-room 6*d.*; urinal free. In the poorer districts the charge is reduced to 1½*d.* for wash and brush up.

In all cases a clean towel is allowed for each person. Where urinettes are provided in women's section, the charge for use is ½*d.* In most districts the attendants are authorised to allow free use of w.c. to obviously poor persons who express inability to pay, and one of the compartments is specially set aside for this.

The Shoreditch conveniences are open from 6 a.m. till 12 midnight on each week-day, and from 7 a.m. till 11 p.m. on Sundays. Bank holidays as Sundays.

The time is divided into two shifts for the attendants, whose wages are for men 27*s.*, and for women 18*s.* per week of six days. For Sunday and holiday duty the extra men receive 4*s.* 6*d.*, and the women 3*s.* per day.

Cost.

The actual cost of the conveniences herein illustrated was:

For No. 1 (opposite Shoreditch Church)	£2450
„ No. 2 (Hoxton Street) . .	2000
„ No. 3 (New North Road) . .	1650

In each case whole tenders were invited. The cost of these per cubic foot averages about 3*s.*

The period of repayment of loan allowed by the Local Government Board is thirty years; this makes the annual instalment on the 2450*l.* borrowed for No. 1, amount to about 82*l.*, and the maximum amount of interest at 3 per cent. to 73*l.* 10*s.*

The administration and other costs are about 475*l.* per annum, making a total expenditure of 630*l.* 10*s.*, which includes for the maximum amount of interest; and this data may be taken as fairly proportionate to the cost of the others existing in Shoreditch.

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That the provision of these structures will in the true sense of the word be a convenience for the general public, is sometimes made a subservient factor by their representative Councillors, the question they mainly consider being whether such a place will be a source of profit over and above the cost of maintenance, administration and annual charge for repayment and interest where a loan has to be taken up. But even allowing for these, and losing sight of the fact that a valuable property is gradually being redeemed, the receipts from conveniences in an average busy district, sometimes prove them to be fairly remunerative institutions: indeed, some of the best known sanitary engineering firms are disposed to construct and undertake their upkeep and working in certain selected places, and to pay to the respective local authority an annual sum for the privilege, thus ensuring no loss for the rates to bear. The practice is of course to be deprecated, and in any case we should try to impress on our employers, that these structures are conveniences for the public rather than mere profit-earning institutions.

DISCUSSION.

Mr. HUGH NETTLETON: I have very much pleasure in moving a vote of thanks to Mr. Dixon. This is a subject upon which I am somewhat interested, because lavatory accommodation in connection with Weston-super-Mare, the town which I represent, is inadequate for the requirement of visitors. The Author of the paper has evidently not had the difficulties to contend with that I should have in providing underground conveniences. I should assume that at Shoreditch the ground is not saturated with water, as I do not find any material described for rendering the walls watertight. The subsoil water at Weston is within 3 or 4 feet of the surface of the ground, and before erecting such a structure it would be necessary to provide at least 12 inches of well puddled clay on the outside of the concrete. Another point mentioned by the Author, and one which I think most important, is that the sewers were a proper depth. Our sewers are not deep enough being only about 5 feet deep. I understand there are a number of systems of raising sewage. One firm will undertake to provide an apparatus to raise the sewage of a

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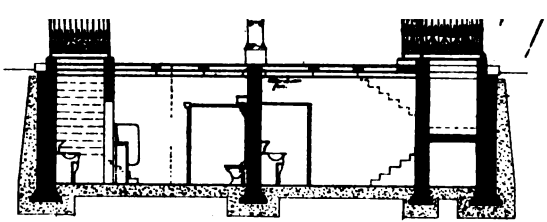

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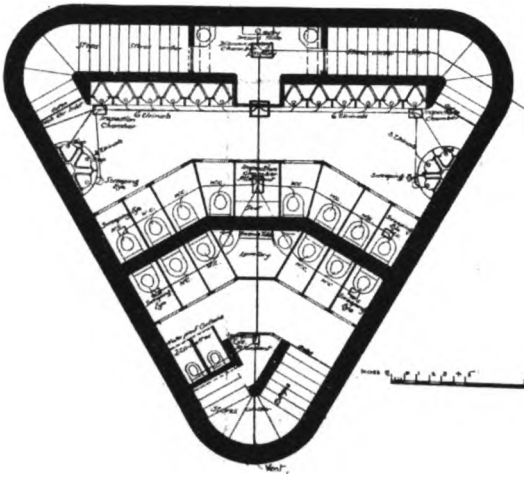

SCALE.

PLAN

J. RUSH DIXON AMICE.
BOROUGH ENGINEER & SURVEYOR
COMPLETED MARCH 1898.

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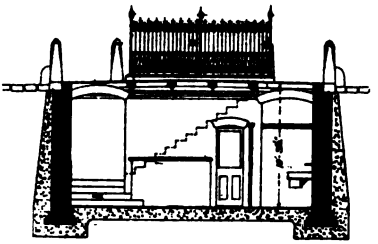
UGH OF SHOREDITCH
OUND CONVENIENCE, HOXTON ST.



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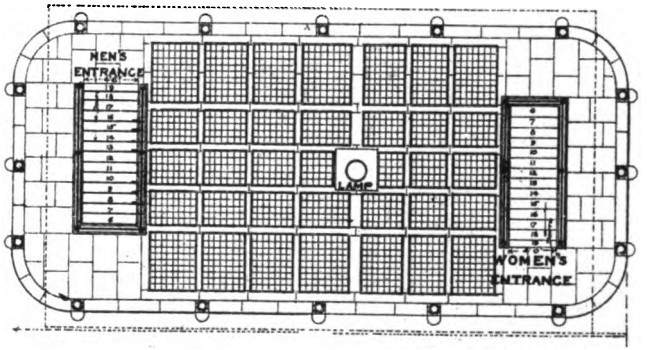

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B

SURFACE PLAN

J. RUSH DIXON A.M.I.C.E.
BOROUGH ENGINEER & SURVEYOR.
COMPLETED APRIL. 1899.

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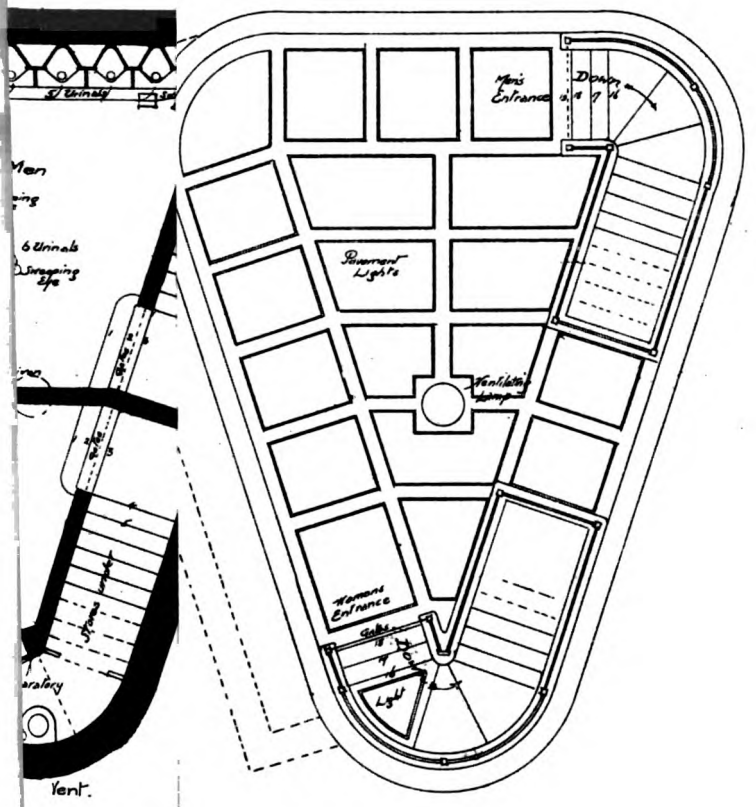
No 3.

North Rd.



Plan above Ground.

J. Rush Dixon. A.M.I.C.E.
Borough Engineer & Surveyor.
Completed March 1898.

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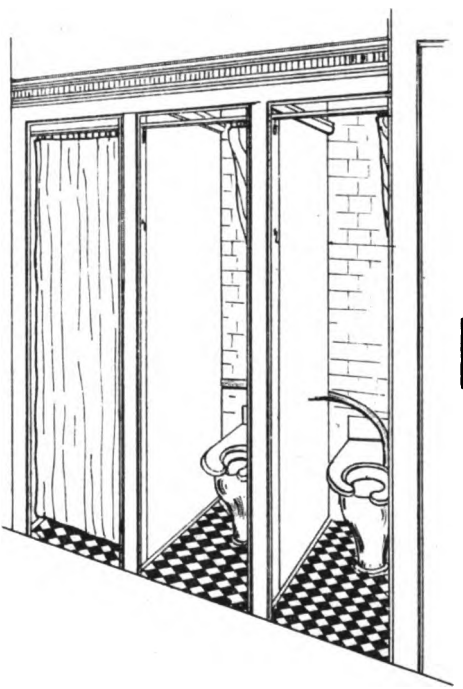
BOROUGH OF SHOREDITCH

SKETCH OF URINETTES IN UNDERGROUND CONVENIENCES.



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small underground convenience about 5 feet for 200*l.* I should like to ask whether in the experience of any Member of this Association these apparatus have been found reliable and trustworthy.

Mr. W. WEAVER: I have very much pleasure in seconding the vote of thanks to Mr. Dixon. The paper does not deal with a high type of engineering but it touches upon a branch of municipal work upon which the comfort, to some extent, of the inhabitants of the town depends. Therefore it is a subject which may engage the attention of those interested in the welfare of towns, but like most sanitary work it is liable to be overdone. Underground conveniences were started as an economical and paying venture, and in many busy thoroughfares of London they form a distinct and profitable item of revenue to the ratepayers. But suburban districts, imitative of their brethren in the more central districts, have gone in lavishly for these conveniences where the revenue to be obtained cannot recoup the outlay. It behoves these authorities to see that, in their enthusiasm for these conveniences, they do not put 2*d.* or 3*d.* on the rates. I should like to ask Mr. Dixon as to his experience with urinettes, because I am rather loth to go in for these in the future. If the experience of other districts is the same as my own district, it behoves us to hesitate as to adopting these urinettes.

Mr. O. E. WINTER: I have carried out several conveniences in different parts of London on somewhat similar lines to those described by Mr. Dixon. I do not agree with him that thirty years is an unreasonable time for the Local Government Board to sanction a loan for such structures. With regard to the damp course which our friend from Weston is concerned about, I have arranged for a vertical and horizontal asphalt damp course, which I have found effective. As to the difficulty alluded to by Mr. Weaver, I have not provided urinettes, but in all structures I have erected both for men and women there has been provided a free water-closet. We have had very little trouble with these and very little abuse. With reference to the construction of these conveniences in smaller districts, where expense is a consideration, much saving might be effected by using more concrete and less brickwork in the structure—in fact I think that concrete altogether, with the use of such a tile as the Doulton-Cockrill tile, would be pleasant to look at and

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would be much cheaper than the construction of 14 or 18-inch walls as shown on the drawings.

Mr. A. E. COLLINS: There seems to be a charm about these underground conveniences to some people. It seems to me that there ought to be a medium between these underground conveniences and the old cast-iron structures. I think that an overground convenience, architecturally treated, need not be an eyesore, and could be provided at a much smaller cost than those underground.

Mr. J. LEMON: I confess I do not know where the water-closet ends and the urinette commences. I fail to see why a poor woman should be charged even a halfpenny when no charge is made to a man. Reference has been made to the great cost of these underground conveniences. Because you build them underground the idea has gone about that you must dress them up with white glazed bricks and all sorts of expensive ornamentation. I should like to say to Mr. Nettleton that if the water is only 3 or 4 feet below the surface it is no place for underground conveniences, and he must put them above ground. A nice tastefully constructed convenience may be erected above ground without all this great cost. Underground conveniences are all right for certain places, but local authorities appear to have got the idea into their heads that they must now go underground.

Mr. W. NISBET BLAIR: We all admit that conveniences, leaving out the word "underground," are necessary. In some places they must be underground; in other places they may, without being very unsightly, be above ground. In my own district I have proved that it may be more economical—in fact, it can be done at a cost one-fourth that of an underground convenience—to rent a small shop and utilise that for this purpose. On the one side have an entrance for men, with a small tobacco store, and on the other side an entrance for women, with a little store of fancy articles. You may not have to incur the cost of the structure at all, only the cost of the fitting. I admit that the system of underground conveniences is being ridiculously overdone. I agree that the same accommodation should be provided for women as for men and at the same cost. We have agreed to provide a free closet for those who cannot afford to pay. I do not sympathise with the construction of these urinettes, and they are, of course, not available to the same

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extent as the ordinary closet. There is also the disadvantage that where you give women the use of a free closet it is abused. The suggestion I have made for utilising an above-ground existing building is one which I think could be developed with very great advantage.

Mr. G. W. LACEY: I should like to add my thanks to Mr. Dixon for his paper and to protest against the costly type of underground convenience. It is all very well to get everything done in a superfine manner, but every place cannot afford it. There is no doubt that conveniences constructed above ground are much cheaper than those below ground. I have just constructed a convenience, stone outside and bricks inside, with five circular backed urinals and three water-closets. The construction works out at a cost per cube foot of 1*s.* 1½*d.* The total cost was about 140*l.* The woodwork was in deal, and the urinal fittings were not of the ultra best. The closets are provided without having an attendant and we find that the greatest abuse takes place with the automatic locks on the doors of the water-closets,—attempts being made to get in with discs, pieces of lead and all kinds of things. So far as the inside of the closets is concerned there seems to be a tendency in some people when there is a new thing to abuse it, but now instead of scattering the floor with the paper and throwing it into the pan they are taking to treating the conveniences with a little more respect.

Mr. W. HARPUR: I really think there is a good deal in the suggestion of Mr. Blair which requires consideration. I think it is an admirable suggestion. I have instructions from my Health Committee to look out for suitable premises for such a convenience in a central position at Cardiff. If a shop is taken on lease on reasonable terms and a convenience provided with perhaps a tobacco shop next the entrance for gentlemen, and a sweet shop next the entrance for ladies, it will probably be found much less objectionable than the form of underground convenience now so much in favour, and I am convinced that ladies would have less objection to entering these premises than the present underground conveniences in conspicuous central positions. I hope attention will be given to Mr. Blair's suggestion.

Mr. E. G. MAWBEY: We had very great trouble in finding a proper site for an underground convenience for women, and accordingly I advised the Committee to provide an overground convenience. I tried to obtain several small shops, and I put

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members of my staff on to look out for suitable premises, but failing to obtain such a place we put up a temporary erection on some waste land in our possession. This proved to be a great convenience and was much used. Then we sold that land at 20*l.* a yard, and since then we put up a little permanent place just opposite to the municipal offices. That place has been a great boon to the females of Leicester. They do not hesitate to go in there, and it is also used as a sort of a little parcel office. We provide a free closet, but it is not abused. We find that people who can afford to pay a penny do pay, because they get into a place which they consider more respectable. Therefore, I heartily support Mr. Blair's suggestion. The price of construction mentioned by Mr. Lacey at 1*s.* 1½*d.* per cube foot is very cheap. In Leicester the price works out at 2*s.* 4*d.* to 3*s.*

Mr. BLAIR: It is 3*s.* 6*d.* in London.

Mr. J. A. BRODIE: In Liverpool we have had for a considerable number of years an arrangment such as described by Mr. Blair. It was not found a success because in a good class neighbourhood ladies would not enter. Then as to rent,—there is such a thing as paying away in rent what you are saving in capital expenditure. I know places where it is cheaper to put in an extensive underground convenience than to pay the rent which would have to be paid above ground.

Mr. J. RUSH DIXON, in reply, said: This is not the highest form of engineering, but Mr. Weaver well knows we have to carry them out and make the best of it for our respective authorities. In Shoreditch we charge ½*d.* for the use of urinettes, but in the case of obviously poor people the attendants are authorised to permit the free use. The experiment of a free place altogether was tried, but had to be stopped through abuse. As to the question of the subsoil water level, so far as I have been concerned there has been no difficulty, and I have not had to contend with water; a vertical and horizontal damp course is always provided. It has been said that the provision of these underground conveniences is being overdone. In Shoreditch we have not built any convenience until we have received petitions, numerously signed, asking for them. They are not in the habit of wasting much public money in Shoreditch. On the five conveniences which we have built there would have been a handsome profit realised, but for the payment of the interest and heavy instalments in repayment of loans within

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30 years. On three of them we do not make a profit, while we take into account those redemption charges, but on the other two there is an increasing profit of something over 400*l.* a year. I like Mr. Blair's suggestion of a shop for the purpose, and I also like Mr. Collins' idea of a special structure built overground and architecturally treated. In reply to Mr. Lacey, I wish we could build conveniences in London at 1*s.* 1½*d.* per cubic foot, but they will have something better. Our cost of construction works out at something like 3*s.* a cubic foot.

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SOME POINTS IN THE CONSTRUCTION OF THE CONTINUOUS SEWAGE FILTER.

By F. WALLIS STODDART, F.I.C., F.C.S.

During the past two years a considerable number of continuous sewage filters have been erected, and as the actual construction has in all cases been left in the hands of the several engineers concerned, a large body of experience has accumulated with regard to the original form of the filter, and to such modifications as have suggested themselves in practice. It has been thought that a brief record of this experience may be usefully presented to this Association.

The main principle underlying this type of filter is of course generally understood, and may be stated to be the preservation of the interstices of the filter as air spaces in the freest possible communication with the external atmosphere.

There is evidence of some weight to show that the ventilating currents essential for providing the necessary supply of oxygen follow closely the course of the liquid applied to the filter, and that the vertical continuity of the air spaces is of more importance than the horizontal; from which it follows that there must be no hindrance to the access of air to the surface and base of the filter. Experience proves indeed that, whilst no appreciable difference can be detected in practice between a filter wholly open at the sides, and one so enclosed as to leave the base only in communication with the air, complete closure of the sides and base of the filter (with the exception of course of an outlet for the effluent) results in a total cessation of its oxidising action. A primary consideration therefore is that the filter body, especially as regards its base, must not be enclosed within impermeable walls. There will probably be little difference of opinion on this point; but in view of the fact that as lately as within the

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last few months filters presenting this radical defect have been erected, a word of caution appears necessary.

Passing to the construction of the filter body itself, it is necessary to point out that there are three chief contributing factors to the ultimate closure of the interstices of the filter, and therefore to the cessation of its activity after a longer or shorter time, whatever its relation as a whole to the external atmosphere. These factors are, in order of importance, the disintegration of the medium, the deposition of sewage solids, and coating of the medium with organic growth.

Of these by far the most serious is the first, because the resulting fine material is quite permanent, and resists biological destruction. However carefully the filtering medium is prepared, fine gritty dust appears at the outlets of the filter, at first in a considerable quantity, later (but for a prolonged period) in smaller traces. Means of ensuring its removal must therefore be provided.

Sewage solids in the very finely divided condition in which alone they should be allowed to pass on to a filter, are largely amenable to microbic action, and indeed are not recognisable in the effluent from a filter in good condition; by themselves they will not do more than temporarily depress the action of a well-constructed filter, but of course they will materially add to the mischief caused by the retention of the stable clinker débris.

The third factor, organic growth, is of two kinds, according to its position. That in the interior of the filter, at a greater depth than about 6 inches, rapidly assumes a permanent condition, and can therefore be satisfactorily allowed for. Upon the surface of the filter, however, as is well known, a more or less continuous layer of fungoid matter frequently forms, varying in extent and thickness from time to time, and may interfere with the proper feeding of the filter. It is probable that the best remedy for this condition is a superficial layer of very large clinker, so that the growth is unable to extend from particle to particle.

It has been suggested that the formation of this growth is promoted by the continuous dropping of tank effluent upon the same spots, and is obviated by the use of the intermittent appliances of short period known as rotating sprinklers. This suggestion, for which there are no scientific grounds, is completely disproved by the experience at Bristol, where of two

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continuous filters, and one filter fitted with an intermittent sprinkler, all being supplied with sewage of similar domestic character, the last alone has developed a "blanket" growth of a troublesome kind.

Now these materials, and especially the clinker dust, are, under the influence of the continuous flow, constantly making their way to the base of the filter, and if arrested there will, more and more rapidly as they accumulate, destroy the action of the filter. Means must be provided for their escape; and the first to be considered is the design of the floor. The form originally suggested, namely a plain surface sloping towards the nearest exterior, has proved in practice to be the most effective, whilst it also lends itself to the conditions of ventilation noted above. The even sweep of the liquid over the plain surface seems to keep it clear of obstructions, as shown by the uniform discharge of effluent at all points in the circumference of the filter.

The introduction of channels, especially if associated with inclined surfaces not in the direction of flow, is found to check the current, and to encourage the local deposition of solids.

Next in importance is the grade of medium, the selection of which is necessarily a matter of debate, since two directly antagonistic considerations have to be weighed. The capacity for work of the continuous filter is in direct proportion to the extent of surface offered by the medium, and that surface is obviously greater the smaller the particles of which that medium is composed. The most active filter therefore will be that in which the grade of material is finest, provided the interstices are kept open. The latter proviso demands a certain coarseness of medium in order to prevent choking by the agencies already referred to.

Now a long and tedious series of experiments has shown that coarse sand becomes ineffective in a day or two, $\frac{1}{4}$-inch clinker in three months, $\frac{3}{4}$-inch clinker in seven months, and so on. On the other hand, the 3-inch material ultimately adopted was deliberately chosen as being entirely free from tendency to choke, and this is so valuable a feature as to render it worth while to sacrifice a certain amount of additional temporary efficiency to secure it.

It is, however, quite open to others to maintain that it may be possible by means of an improved material, and perhaps at

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the expenditure of some trouble in cleansing, to keep a finer filter open, and obtain increased efficiency.

It is probably the desire to retain the use of a fine medium that has led to the introduction from time to time of various systems of aerating pipes into the body of the filter. This is a perfectly useless proceeding. If the medium at the termination of the pipe is impervious, the latter is useless: if the interstices are open, aeration will look after itself.

In any case one layer of 6-inch material on the floor is advisable.

Reference has already been made to the question of a retaining wall, and to the necessity of freely piercing any such wall at its base. On grounds of economy alone it would seem advisable to dispense with masonry altogether. Furnace clinker, which up to the present has given the best results of all the numerous materials tried, forms an excellently coherent bed, the outer surface of which may be almost or quite vertical without danger. The appearance is by no means bad, and the least possible obstacle is offered to aeration. As an instance of the danger of departing, even to a slight extent, from the conditions here laid down, mention may be made of the continuous filter erected at the Manchester sewage works, since it has already been made the subject of a public report.

In this case, although the upper part of the filter is retained by spaced boards only, the lower part, to a depth of about two feet, was sunk in the soil, egress for the effluent being provided by two 2-inch pipes. The floor of the filter was dished to the centre. The effect, as was foreseen, has been exceedingly unsatisfactory. Not only is there a total absence of the essential basal aeration, but there is no free exit for the solids, and no doubt the greater part of the filter after a few weeks' flow became completely closed, especially as coke, the medium used in this case, is known to be very friable. A subsequent attempt to improve matters by digging away the soil on two sides did not lead to the desired result, partly because the mischief was already done, and partly because it effected no improvement in the faulty direction of the flow which remained as before, directed towards the centre instead of towards the circumference of the filter.

In reference to the method of feeding the filter, it will only be necessary to state here that the most satisfactory will be that which in the most economical manner combines the most com-

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plete comminution of the liquid with the least expenditure of force and the least disengagement of odour, due importance being also given to the conservation of fall. If, as is undoubtedly the case, the maximum amount of work is to be obtained from a given volume of filter body by uniformly maintaining the proper proportions of liquid and air, there can be no advantage, but, on the contrary, a loss of efficiency, in arranging for alternating periods of rest and overdosing. The distributing apparatus therefore should work perfectly uniformly over long periods of time, and should, if possible, be practically independent of supervision. These features are combined in the distributor, which forms an essential part of the continuous sewage filter.

This apparatus was fully described by your President at last year's Conference,* but in order to correct a wide-spread error in its mode of application, it is necessary to recall that it consists of a number of narrow gutters inserted at both ends into specially designed channels which both feed and support them. The whole of this system must be laid perfectly level, no fall whatever in the supply channels being required. The escape of liquid from the distributors is so free and unimpeded, that with the maximum flow along the channels no measurable rise in level is apparent. The system of channels may be directly connected with the outlet of the tank, their floors being flush with the invert of the latter: if circumstances necessitate a length of channel between tank and filter, a baffle chamber should be interposed to steady the flow. In several instances the supply channels have been laid with a distinct fall, and the effect has been, of course, to feed only the most distant distributors, and even those irregularly.

There are two matters connected with the use rather than the construction of this filter which may be usefully mentioned here.

It is surprisingly rare to find sewage works with an efficient means of gauging the flow, and the trifling display made by the drops of liquid falling from the points of the distributor is so deceptive that these filters are commonly, though unintentionally, much overworked. It should be remembered that one drop per second from each point is equivalent to a flow of 22 gallons per hour per square yard, the full dose for a 3-foot filter; and that, assuming that only one-fourth of the points are working, each

* *Vide* vol. xxvii. p. 266.

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should deliver only four drops per second. It is almost impossible without direct measurement to persuade the inexperienced observer that the total flow is so considerable.

Secondly, it has been pointed out elsewhere that a dilute tank effluent is more amenable to treatment than a strong one, because the additional water provides means of applying more dissolved oxygen to the oxidisable impurities. In many localities there must be a considerable quantity of more or less polluted and useless subsoil water, the removal of which from the neighbourhood of dwellings would add to their healthiness, and which at small expense could be brought into the works, and there added to the tank effluent before its application to the filter. By thus increasing the total volume to about 50 gallons per head of population, the oxidation of the organic impurities would be greatly facilitated.

The Effect of Frost on the Continuous Sewage Filter.

It has frequently been suggested that prolonged and severe cold must prejudice the bacterial treatment of sewage by inhibiting the activity of micro-organisms generally. However true this statement may be of some steps in the process, there are no good experimental reasons for assuming it to extend to the final stage of oxidation. The known persistence of nitrification in the surface soil throughout the winter, and some direct experimental proof that rise of temperature tends to stay the series of changes at the penultimate stage of nitrosification, are sufficient to throw doubt upon the cessation of biological oxidation at temperatures short of actual freezing; whilst the largely increased solvent power of water for oxygen at low temperatures is of course a favourable factor.

However, there are mechanical as well as biological matters to be taken into consideration, and the prolonged frost in February of this year afforded a welcome opportunity of ascertaining whether the continuous sewage filter was affected as a whole by a sustained low temperature.

The frost commenced with the month of February, but became severe on the 7th and continued so until the 20th.

The observations taken were not so complete as would have been the case it it had been possible to foresee the spell of cold

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weather; but the following tables give such results as were noted, and suffice to show that during the whole of the time nitrification was fully maintained, whilst the incubator test proved the effluent to be uniformly imputrescible.

TABLE No. I.—HORFIELD CONTINUOUS SEWAGE FILTER.

Relation of Temperature to Nitrification.

Date.	Minimum Temperature of Air, Fahr.	Nitric Nitrogen per 100,000.
Feb. 7	24	Greater than 2·0
8	26	
9	25	
10	21	
11	18	
12	18	
13	15	
14	18	2·90
* 15	19	2·75
16	20·5	
17	18	3·10
18	21	2·75
19	32	
20	32	

* TABLE No. II.—ANALYSIS OF FILTER EFFLUENT, FEB. 15.

Parts per 100,000.

Saline ammonia	9·1
Albuminoid ammonia	0·33
Nitric nitrogen	2·75
Oxygen absorbed in 4 hours at 80° F.	1·51
Chlorine as chloride	11·70

The first table shows the actual minima of air temperature during this time and the determinations of nitric nitrogen on the later days; the figure on the 17th was corroborated independently by Dr. Rideal. The lowest temperature noted for the effluent from the filter was 35° F. The second table gives

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the analytical data furnished by the effluent on February 15. Considerable freezing occurred in the distributors, especially at nights; and the outlets and lip of the filter were thickly coated with ice: the action of the filter, however, as a whole was entirely unimpaired; and it appears unlikely that the cold in this climate will ever be sufficient to cause any interruption in working.

DISCUSSION.

Mr. E. J. SILCOCK: I beg to move a vote of thanks to Mr. Stoddart for his paper. It is well for us to have every opportunity of discussing this question, and of accumulating as much recent information upon it as possible. With regard to the points raised in the paper, I am glad to find that Mr. Stoddart is so impressed with the proper aeration of the bottom portion of the filter. I have not had an opportunity of hearing Mr. Stoddart's views before, and from the construction one would imagine that he had not attached so much importance to that particular part of the structure as some other advocates of continuous filtration have done. The method of construction adopted in some places is to have a perforated bottom supported by the floor and the filtering media laid upon that bottom. It appears to me in that way a more perfect aeration is obtained. I agree with Mr. Stoddart that the proper aeration of the bottom of the filter is of great importance, and it does appear to me that some improvement may be obtained in this filter by adopting some form of perforated floor above the solid floor. With reference to the degradation of the filtering material, it seems to me that the great difficulty which has been experienced has been largely brought about by the use of coke for the construction of these and some other filters. It was at first supposed that there was some peculiar inherent quality in coke which formed a suitable nidus for bacterial action. That idea is now discarded, or at all events many satisfactory results have been obtained, notably by the use of clinker, and by other material of less porous and more solid character. My opinion is that the material used in the construction of these filters will have to be of something more solid even than clinker, possibly something in the shape of granite or lava, so as to be more durable and less likely to be

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broken down by the action of the water passing through the filter will be found best. That no doubt will add to the cost of the construction in the first instance, but I am of opinion that the ultimate cost will be reduced by using a better class of material. We find with the use of continuous filters in Leeds, where they are very successful, it is necessary to have in addition to the filter a separate tank to take out the iron, of which there is a large quantity in the sewage. That iron can be taken out by the provision of a small settling tank. The rate of filtration is alluded to in the paper, and Mr. Stoddart warns us against thinking that the rate of flow is a small one, because it comes out in a large number of drops, and the figures which he gives us show that his view is a correct one. He gives a total of 2,500,000 gallons of sewage per acre in twenty-four hours for a 3 feet deep filter. I think we shall all agree with him that that is a full dose. I have never seen a filter only 3 feet deep working at that rate. But then the strength of the sewage must be taken into consideration in estimating the work of a filter, and I venture to think that the sewage must be of a very weak character indeed to produce good results if worked continuously at that rate over a depth of 3 feet. I asked Mr. Stoddart this morning as to the cost of his distribution system. Of course, as engineers we do look at the cost, and have to study the question of finance in connection with the carrying out of our work. Mr. Stoddart was good enough to give me some information. He told me that the cost of the distributing arrangement varies from 10*s.* to 1*l.* per square yard, depending upon the size of the filter. That seems to be a rather important item. The cost no doubt may be reduced by producing in very large quantities and effecting small economies in various ways, but the addition of 10*s.* per square yard for distributing plant to the cost of a filter is a very serious item, and can only be justified by obtaining results which are superior to those obtained in other ways. All I can say on the point is, if Mr. Stoddart can guarantee a purifying efficiency of 2 to 2½ million gallons of sewage per acre on a filter 3 feet deep we shall not quarrel about the price.

Mr. G. W. LACEY: I have great pleasure in seconding the vote of thanks to Mr. Stoddart. I am sure everyone who has to do with bacterial treatment will welcome any paper which throws light upon this important subject. There is no doubt that with a filtering material so large as 3 inches in diameter there must be

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some loss in effectiveness, though you get a larger amount of liquid through the filter than with a material of finer size. I cannot agree with Mr. Stoddart that a filter, so far as the larger gauges are concerned, is going to be uneffective in the time stated in the paper. Mr. Stoddart says that ¾-inch clinker becomes uneffective in seven months. My beds are composed of cinders from ½-inch to 1¼-inch size, and we did not find they became uneffective in so short a time as seven months, although after being in use for four years there has been considerable loss of capacity. It has occurred to me whether, with this continuous flow system, there is less tendency for the material to disintegrate and to become closed than where the filter is a contact bed. There is no doubt, with this type of filter, you must have plenty of aeration. I have no doubt Mr. Stoddart will advise that this method of distributing the liquid over the beds is equally good for distributing it over contact beds. Then he rather suggests taking into the sewers the subsoil water. That is a large order and one which many engineers will hesitate to advise their councils to adopt. If you are going to increase your flow by 100 per cent., you are going to seriously increase the cost of construction and maintenance. As to the cost of the distributor, which has been spoken of as from 10*s.* to 1*l.* per square yard, I am rather of opinion that anything approaching that cost will in ninety-nine cases out of a hundred be prohibitory. As to the analysis given in Table II. of the sewage of Feb. 15, I should like to ask whether the result is from one contact, also the strength of the sewage, and whether we can ascertain the percentage of purification obtained under this principle. It would be interesting to those who have works on other lines to compare the results obtained by this system with those obtained by primary contact beds. I should think there would be some difficulty in the winter time from the freezing up of these orifices in the gutter, and it occurred to me whether there would be any blocking up by the accumulation of sludge, but from the orifices being in the apex of the triangular section that is not so likely to happen. In a large sized bed, you would have to arrange pillars to carry the troughs and gutters across. There is no doubt the better distribution you get over the whole area of the beds the better results you obtain than with a casual distribution over parts of the beds.

Mr. R. A. MacBrair: We visited the works at Sea Mills this

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morning and were kindly shown the filter by Mr. Stoddart. I must confess—and my feeling was shared by two or three colleagues with me—that the effluent was hardly of that purity we had hoped and expected to see. Of course there may have been circumstances which had brought that about. I am afraid that in my district we should scarcely be satisfied with the effluent. Perhaps Mr. Stoddart will explain why the effluent was not so good as was expected.

Mr. J. HALL: I think the question of the quality of the effluent is one which may very well be considered. I have found that with somewhat similar treatment of sewage, the effluent must be put over land. I should not consider any effluent I have seen from a continuous filter fit to go into a stream. I have had a very similar filter working for ten or eleven years. It has been opened twice in that time. The last time it was working for seven years uninterruptedly. When the effluent from a continuous filter is put over land it makes the vegetation much more luxuriant than crude sewage. The filtration appeared to have prepared the sewage for the land to take it. I am sorry to have to say a word about the arrangement of the distribution over the filter, but some of us have been using a somewhat similar arrangement for distribution with corrugated iron with holes punched through, and it has answered admirably.

Mr. A. P. I. COTTERELL: I can bear testimony to the amount of attention to detail. Mr. Stoddart has given the production of a better kind of filter than that which formerly existed. I think that that is the essence of Mr. Stoddart's invention to bring to the use of engineers a more efficient mechanical filter than they had hitherto possessed. The distribution is arranged in a way which makes the filter work over its whole area and depth which was a drawback to many previous types of filters. The only other kind of filter that competes with it is the contact filter, and this cannot deal with so large a volume per square yard as Mr. Stoddart's will. The experience I have had of the essential method adopted in Mr. Stoddart's filter, viz. that of applying the liquid drop by drop, proves to me that you certainly get a larger amount of purification per square yard by this method than by any other means that I know of. The quantity mentioned by Mr. Silcock of two to two and a half million gallons per acre in twenty-four hours, or 500 gallons per square yard, is not at all out of the way. I am very glad that Mr. Stoddart put before

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us the idea of designing filters for the amount of work they have to do rather than for the amount of liquid they have to pass. We are so accustomed to talk of the amount of liquid a filter will purify, without taking into consideration the strength of the sewage that it has to deal with, that the reminder was certainly needful. There is also another point with regard to this filter and to a large extent all filters—certainly those that are continuous in their action—to which I should like to draw attention. For the sake of cheapness we have come to use coke, clinker and stone for filtering media, but I cannot help thinking that none of these are the most satisfactory that could be obtained. Their function is of course to provide in their interstices or on their surfaces suitable places for the bacteria to work from. This they certainly do, but much of the cubical space of the filters is after all wasted and the filter cannot be in a state of the highest possible efficiency. If we could turn our attention to improving the material of which the filter is constructed so as to get an indestructible material with a maximum of surface for the bacteria to work from, I believe that we could put an even larger quantity of sewage upon a square yard than Mr. Stoddart does in his system.

Mr. STODDART, in reply said: Mr. Silcock has advocated the use of a perforated bottom on the floor of the filter. The only objection to this suggestion is the expense of construction. I agree that coke is an unsuitable material to use in a filter owing to its friability. With regard to the rate of flow of the sewage through the filter, which Mr. Silcock considers excessive, he has rather embarrassed me by basing his criticism upon beds 3 feet in depth. With beds of 6 feet in depth there is no difficulty in dealing with a flow of sewage up to 5 million gallons per acre per day. The theoretical capacity of the filter at Horfield is for 4000 people. The actual population dealt with is 1500, plus the barracks representing another 1000, or 2500 in all. The actual cost of construction of the filter, including the removal of the old beds, was 268*l.*, which on the basis of a population of 4000 persons, means a capital outlay of 1*s.* 4*d.* per head, and on the basis of 2500 about 2*s.* 1*d.* per head of population. That is the capital outlay without taking into consideration the working expenses which are practically nil. As regards the closing up of a continuous filter as compared with contact beds, I think the advantage lies with the continuous filter because the constant

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and copious flow must tend to clear away the intercepted solids, whereas the mode of working a contact bed helps to retain them. In reply to Mr. Lacey, I may say that I do not advocate the introduction of subsoil water into the sewers, but its admixture with the tank effluent before passing it on to the filter. The additional quantity of water assists the action of the filter owing to its solvent power for oxygen.

Mr. LACEY: What is the average chemical purification effect?

Mr. STODDART: The average purification is 70 per cent. on the tank effluent. In answer to Mr. MacBrair, I may say that the effluent from any continuous filter always contains suspended solids, otherwise the filter is not sufficiently open to effect aeration, but they are readily separated by a catch-pit. In answer to Mr. Hall, I prefer the use of a catch-pit to passing the effluent over land, though the effect of the effluent on vegetation is exceptionally good.

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MOTOR VEHICLES FOR BOROUGH AND COUNTY WORK.

By E. MANVILLE, M.I.E.E.

That there are great possibilities for the self-propelled vehicle in connection with borough and county work few will deny, but it is doubtful whether the full extent of the numerous purposes to which it can be put is fully realised at the present moment, for, unfortunately, but few really serious attempts have so far been made to utilise the new form of locomotion in this direction; and the Author therefore trusts that the few following remarks he has to make on this subject may serve as a basis for reflection in the minds of Municipal and County Engineers, as to the possible application of motor vehicles towards facilitating their work, and decreasing the costs that are at present being incurred by the employment of horse propulsion.

Up to the present some of the more enlightened local authorities have organised services for street watering and dust-collection by means of motor vehicles, and, moreover, some attempt has been made in one or two cities to employ the motor in connection with fire brigade work.

The scope of the automobile is so far-reaching, that these experiments are comparatively insignificant, and give but the slightest idea as to the greater results eventually to be secured.

The design and construction of the self-propelled vehicle have to-day reached a standard of excellence which renders it eminently suited to all classes of work; and serious consideration should be given to the claims put forward on its behalf. The main questions are economy and reliability of running, and, perfected as it now is, the motor vehicle embodies both qualities to a very marked degree.

Proof of this assertion is afforded by the official returns of

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the trials organised at different times by the Automobile Club and the Self-propelled Traffic Association; moreover, reliable evidence on these points is readily to be secured from the many private owners who make a practice of noting down valuable data relative to their motor vehicles.

There are cars such as the Daimler—one of the best known existing types—which for years past have been running week after week and month after month at a cost for fuel of $\frac{3}{4}d.$ per mile. Good results, however, are only to be secured by the employment of a thoroughly capable mechanic. No greater mistake can be made than to commit to an inexperienced man the charge of a motor vehicle, and no doubt many have false impressions as to the cost of maintenance of motor vehicles owing to the repairs that have been necessitated by the absence of intelligent care on the part of the individual whose duty it is to clean and adjust the somewhat delicate mechanism of the car.

The initial cost, the expenses of maintenance, and the rate of depreciation are all points demanding consideration; but no comparison can be made between a motor vehicle and one drawn by a single horse, as is only too frequently the case, for one of the former will do the work of at least three of the latter, and it is on this basis only that any attempt in the way of comparisons of cost should be made.

Again, false impressions of the costs of maintenance of motor vehicles are obtained by the use of unsuitable types. The smaller and more lightly constructed vehicles, whilst eminently adapted for occasional use for pleasure purposes, are not nearly so suitable for constant daily heavy work, and in such cases vehicles of a more substantial type at a considerably greater capital cost should invariably be employed, and under such circumstances it may very well be said that, within reasonable limits, the greater the capital cost of the vehicle the cheaper its ultimate cost in maintenance.

Motor carriages can be employed by Municipal and County bodies in many different ways. What better means of conveyance could be adopted by city engineers, county surveyors, chiefs of police or fire brigades, or other civic officials whose duties so often require prompt attendance at some distant spot? A couple of minutes after a hasty summons, a motor carriage could be got away, and, running rapidly and smoothly through the traffic,

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convey the fire brigade chief to some fierce outbreak or the chief of police to the scene of a disturbance. No waiting for preparations, but an instant departure, and a journey made at a speed as fast as it is untiring.

That some chiefs of fire brigades realise the ability of the motor vehicle received corroboration only a few weeks ago, when many of the illustrated papers reproduced pictures showing Mr. Croker, the head of the New York brigade, seated in his car.

Successful tests in this direction were also made with the Daimler carriage in one of the Midland towns a little time since.

City engineers and county surveyors should also gladly welcome a light, fast and reliable vehicle, as by its means their duties could be much more expeditiously performed, and they would be always assured of quick arrival at any given spot when urgent need arises.

The county surveyor and his principal assistants should find motor vehicles almost indispensable to facilitate their work, for the extreme length of the journeys these gentlemen have to take makes the motor vehicle incomparably the best of existing means for getting about the roads; and, as a secondary but by no means unimportant consideration, should be borne in mind the fact that the mere act of a motor vehicle travelling at a comparatively fast pace over the roads would enable him to determine the condition of the latter and their comparative need of repair.

Again, local authorities who have electric and other tramway systems under their control might well avail themselves of motor vehicles, both for the service of their engineers in inspection of the lines, and for the conveyance of repairing gangs, etc. A large tramway company to which the writer is one of the engineers has actually availed itself of this method of transporting its engineers; and also the Compagnie de l'Est Parisienne has done the same thing for years past.

Workmen engaged upon laying and repairing roads and gas and water mains might be carried cheaply and expeditiously, together with their tools and materials, to the point at which the work is proceeding.

Motor water and dust carts are already in use, but only to a limited extent: yet they perform their duties so admirably, that considerable expansion in this direction may be safely anticipated, and with it the appearance of self-propelled street

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scavengers and other machines of special design for the public service.

Very naturally, constructors of motor vehicles are chary of launching out into the heavy expense which would be involved in designing and constructing special machines of this class, until some encouragement is forthcoming from local authorities, but given that, rapid progress will assuredly be made, and all manner of self-propelled vehicles for heavy work will be brought into practical use.

It therefore follows, that it is largely to the borough and county engineers the motor car trade must look for the initiation of directions in which motor cars may be utilised, and having regard to the well-known enterprise of these gentlemen whose interest it is to see that the cheapest and best methods are used by the local authorities whom they represent, there is little doubt but that the next few years will see a very large extension in the utilisation of these vehicles.

DISCUSSION.

The PRESIDENT: You have heard this paper and I shall be glad to have the remarks of anyone present who has adopted these mechanically propelled vehicles. My experience is of a very limited character and not so pleasant as that of some people. The latter part of the paper touches a useful point, that of motor traction for heavy work such as the transport of dust refuse and such things. For that purpose motor vehicles will come in no doubt and be very useful. Personally, I have an old fashioned liking for the horse.

Mr. E. G. MAWBEY: I propose a hearty vote of thanks to Mr. Manville for preparing this paper. You know what experience we had at Leicester with motor vehicles last year, with the exception of one accident, when a good many of us were convinced as to the advantages to be derived from motor cars. I am myself sanguine enough to recommend surveyors who have many miles of roads to supervise and great distances to travel, to purchase one of these cars, believing they will find them to be advantageous. I must, however, support what Mr. Manville says, and warn you against going in for a cheap

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car. Any gentleman who persuades his committee to buy a car of less than 8 horse-power and costing less than about 400*l.* will make a huge mistake; and the chances are that six or twelve months later he will have to go before his committee and admit this. Personally, I would recommend a 2-cylinder car of not less than about 10 horse-power. With regard to the use of motor vehicles for street work, I have not yet had experience of them; but we are going in for steam vehicles for scavenging work. We believe that the Thorneycroft steam wagons are the best on the market for that work. In conclusion, I do advise the use of motor cars wherever surveyors have long distances of road to look after.

Mr. E. P. HOOLEY: I beg to second the vote. I am pleased to say I have had some slight experience of motoring for inspection purposes. At the present moment motoring is in its infancy and there is often more pleasure to be got out of it than utility. If any one had had my experience with motor cars they would agree with me it is better to hire than to purchase. If you can hire a car at anything like 2*l.* a day, you will find it the better plan. The experience of purchasing a car too often is, that you have an appointment made for a morning, you send round a man for the car, and the induction valve or sparking gear is out of order and you are just as far from keeping your appointment in the afternoon as in the morning. If you hire, you have the choice of about ten cars, and thus you have a second string to your bow which you would find most useful. From an economical point of view, most men who know what a county surveyor has to do with the inspection of hundreds of miles of roads, will recognise the value of a motor car for such work. I used formerly to take a week on the inspection of my urban main roads. In April this year I did in thirty-six hours what had formerly occupied a whole week, and at one-fourth the cost. For health there is nothing like motoring, and any man who has to pass many hours in an office will often find a day's motoring will do him as much good as a fortnight's loafing holiday. Motoring has undoubtedly come to stay, and is going to be of the greatest advantage to us, but do not buy a car at present—hire.

Mr. W. WEAVER: The speakers hitherto have touched upon motors for taking the surveyor about. I will make a few remarks about the steam motor for scavenging work. In the paper I read at the Glasgow Congress I said I was having one

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made, and from the number of letters I have received from all parts of the country, it seems to me that this branch of the subject possesses very great interest to surveyors. I have a Thorneycroft steam-propelled machine, which is partly their own design and partly an adaptation of my own, and has now been at work for five months. It consists of a water-tank of 600 gallons, with water distributors by two modes, one for flooding a road and the other for fine distribution. There is attached to the water-van a rotary brush, which can be taken out in two minutes and replaced by a spiral indiarubber squeegee, so as to get a wiping up action after the cleansing of the wood. After the revolving brushes go over the surface there is a little greasy deposit remaining on the wood which is somewhat slippery for horses to get over, so I adopted this spiral indiarubber squeegee to get over the difficulty. It works extremely well, but, like all new machines, we find various defects in regard to it as we go along. The machine cost 725*l.*, and when at work it does admirably. It works all night in washing and cleansing wood pavements. It will do 140,000 square yards of wood paving in an hour, and when I tell you it will wear out a set of brooms in four days, you will understand there must be some working friction. The defects I have experienced are, a bolt is too weak here, a valve leaks there, oil drops in another place, and so on. I am having another machine made by Thorneycroft in which I have endeavoured to rectify the little defects which have shown themselves in the present machine, and I believe in the course of a year or two's working we shall be able to have a very satisfactory self-propelled street cleansing machine which will be of immense service to borough surveyors. In addition to the wood-cleansing work this machine I use in the winter for sanding the roads. I put on the Willacy sanding machine to the rear of the motor and fill the 600 gallon tank with sand. Two of these machines will do the whole of my roads. So with the use of these two machines I hope to be able to save my entire night staff of horses and men. Hitherto I have been sending out 12 horses, and I hope when I get the two machines at work to dispense with the whole of the horses employed on the night staff. I think it will be a very satisfactory and economical arrangement.

Mr. O. E. WINTER: There is no question that the adoption

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of motors for street work or ordinary haulage is of more practical importance to municipal engineers than travelling about for inspection or pleasure. At Hampstead I have had two Thorneycroft steam motors at work for nine months. They were obtained chiefly for the purpose of dust collection. We had also for this work a trailed van to each motor. The reason it was thought motors would be an advantage more particularly for this work, was because our destructor is three miles outside the boundary of our district. I found there was a good deal of time and value lost while the motor was standing about the street during the collection of the refuse. The result is that compared with horse haulage the motor does not work out economically, even with the use of a trailed van worked in connection with the motor. For the last two or three months I have used the motors for street watering and haulage of road materials, and in this work I find there is a very distinct advantage over horse haulage. Each of the motors is now doing the work of four horses and carts. We pay 9*s.* 8*d.* per day for horse and cart, or 1*l.* 18*s.* 8*d.* per day for four horses. The motor costs, including driver, fuel and all expenses, together with depreciation and an estimated amount for repairs, which I anticipate will be fairly heavy, 28*s.* a day, or a saving of over 10*s.* a day for each motor. The original cost of the motor was 700*l.*, including the provision of two bodies, one for dust collection or road materials and the other for street watering. The motor has a further advantage for street watering as it is fitted with two speeds and also double valves so that we can wash paved roads or sprinkle as required. In the figures I have given I have allowed a rate of 4 per cent. for interest on capital outlay and estimated the life of the motor at seven years.

Mr. W. HARPUR: What are we to do who cannot hire? If we are to have a vehicle at all we must purchase. Mr. Hooley may be in the fortunate position of being able to hire, but that is not the position of most of the Members of this Association. I was going to ask Mr. Manville had he been here as to the cost of maintenance of these motor carriages. I have been told —I do not know whether it is true, for it seems a rather extraordinary statement—that the cost of maintenance and upkeep of a motor will run to 1*s.* per wheel per mile. I do not know whether Mr. Mawbey has sufficient experience to inform us on that point.

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Mr. E. G. MAWBEY: I have no figures available, but I can very flatly contradict that statement as to the cost of maintenance. The Michelin tyre is the best English tyre, and the proper thing is to have extra treads put on the tyres before using them. I have run my car nearly 600 miles in a little over a fortnight, and there seems very little effect of wear on the tyres. You can renew the treads when worn out. A set of new treads will cost you from 8*l.* to 10*l.* You could run a car 50, 60, or 100 miles a day, and travelling those distances you could go on with a single set of treads for months, and you could get them re-placed for 10*l.* So the statement of cost which Mr. Harpur has been informed of is altogether fallacious, though there is no doubt the upkeep of a car is expensive. If you are not so anxious about luxurious riding the Goodyear tyre and the solid tyre have a tremendous life in them. Mr. Manville tells me that for the car which was made for the King by the Daimler Company they put the Goodyear tyre to most severe strains and tests and that it was found to stand remarkably well.

Mr. A. T. DAVIS: I have had no experience with motor vehicles. I am a cyclist and very fond of the exercise, and I think I shall stick to the cycle until the motor vehicle is perfected. In the first place the motor is too expensive, and secondly next you cannot rely upon it. Mr. Hooley is in the happy position of being able to hire a motor, but he says if you purchase one, when you are about to start on your journey perhaps a valve goes wrong or the sparking gear gets out of order. I am in the same position as Mr. Harpur and have no opportunity of hiring a motor vehicle like they have in Nottingham. I shall possess my soul in patience until the motor is more perfect and more reasonable in price than it is to-day.

The PRESIDENT: It appears to me from the discussion there is a future for heavy motors in towns for certain work, and unquestionably in time the cost must be reduced. From what we have heard it is just possible motors may be advantageous for street watering and other purposes.

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AN APPRECIATIVE ANALYSIS OF MACADAM ROAD CONSTRUCTION.

By C. H. W. BIGGS.

This short paper is the result of a remark made during the discussion on Mr. Beaumont's paper at Leicester last year. Chemists and engineers have various kinds of analysis, each kind having a particular use, and at meetings of this kind utility should form the chief factor. The chemist deals qualitatively, or quantitatively as the case may be—and the utility of his labour is often found in synthetic work. An engineer determines the function of every detail of his machine, and fashions and shapes accordingly.

Now a road is a machine. Its functions are complex, but here only the broad commonplace uses will be considered. The main function of a road is to allow the traffic to pass over it with the least possible tractive effort—or to put it another way, to permit the carriage of weight per ton with the least expenditure of energy. The class of material used, the amount of friction between the material and the wheel surfaces, and many other factors might be considered, but that is not my purpose at present.

Broadly speaking, there are two parts to be considered in the construction of a road, and there are details in each part requiring attention. In the first place, every road should have a good foundation—in fact, the Author looks upon the foundation as the most important part of a road; then, secondly, we have a wearable and renewable surface of suitable materials and varying thickness. These two parts of a road differ in that once the foundation is laid it ought never to be tampered with, or touched as little as possible. Without a perfect foundation it is impossible to obtain a perfect wearing surface. This statement needs no proof, for the proofs are to be seen on

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every hand. The analysis of foundations the Author will pass by, and restrict his observations to the "macadam" renewable section. Seventy years ago (in 1832), when Gordon wrote his book upon Elemental Locomotion, urging the value of mechanical traction on common roads, he said, "The more surface resistance is reduced, the easier certainly will be the draught, and the less traction power will be required. This species of resistance is avoided by using hard and durable surfaces in road making."

The macadam section of a road consists of two parts: (1) The hard wearing surface which is supposed to directly carry the load, and (2) the matrix or material filling the interstices between the hard material.

The Author would like to interpolate here that in his opinion all road construction with a wearing section of the macadam pattern is, from a scientific point of view, very imperfect.

Consider each of these parts. The hard wearing surface is of stone broken down to pieces of say not more than 2 inches diameter through the longest section, of indeterminate shapes, but with many sharp edges. The crude idea is that these stones will by some means get into the form of a mosaic with the angular sides fitting in among each other, and so interlocking the mass that separate motion is impossible. Many engineers also use stones of smaller dimensions, which shall fall into the interstices of the larger material and aid the locking process. The idea embodied in this view is not bad, but the means usually employed to carry out the actual work are bad. The Author cannot however suggest a more perfect method except to follow the suggestion of Mr. Beaumont in his Presidential address to the Society of Engineers when he said the best way was to have every stone laid by hand. What is really wanted is a machine that will joggle the stones into a natural position, not a steam-roller which pushes the stones into a position which is not the natural interlocking one, and which does further damage in that the sharp edges of the stones are ground off and the interlock obtained far less perfect. A nice gentle, and for some minutes more or less continuous, earthquake under a newly installed road would provide the joggle—but then you cannot put a brake upon an earthquake, nor command it when required!

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At any rate, the result when the stones are in place should be to give an absolutely smooth surface, with the very slightest space between the stones so as not to break continuity of surface of the road metal.

The second part of the macadam section consists of material to fill up the interstices left between the stones, and this detail has had far too little attention paid to it. Usually the material is sand or road detritus, both of which are bad, neither having a single good property to make it acceptable for the use to which it is put. Either of these materials is easily washed in or washed out. Neither conduces to the solidity of the mass sufficient to keep the stones from motion. After the matrix has been got into position, every part of the macadam section should be identically similar to—and if the Author may say so —have the same specific gravity as every other part. For perfection every cubic foot of macadam should consist of the same percentages of stone and matrix, which should be disposed in similar positions.

The Author has referred to a remark in the discussion last year: it was to the effect that automobiles exerted a very damaging "sucker" effect which played havoc with even the best macadam roads. This sucker effect pulls away the loose dusty matrix around the stones, tends to break the lock of the section and generally to make the road, with an insufficiently resisting matrix, merely a heap of stones and not a good road surface. The remedy in this particular is different material to form the matrix, and it would be a libel upon engineers to say or to think they cannot devise some means to overcome this difficulty. Some have seen the importance of this detail, as may be seen in the use of tar macadam, and in the more recent constructions of Mr. Hooley in Nottinghamshire. The Author's text, however, is analysis, not synthesis.

In conclusion, what is the result under the present system when remetalling a road? Submit the process to analysis. Two systems prevail—perhaps it should be said one system with a few exceptions. The old worn surface is picked by manual labour or by means of a scarifier; the new metal is thrown on and then rolled, with the usual addition of matrix material. Now, unless stones and matrix are equally distributed over equal areas, it is absolutely impossible to so make a road that it will not in a very short time wear in holes and become merely a succession of hills

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and hollows, every one of which accentuates enormously the wear and tear of the road, and, as remetalling is usually carried out, a good surface is impossible, there being no equality of distribution over equal areas of either old or new materials—metal or matrix.

Practically, then, the analysis comes to this, that a road consists—

1. Of a foundation which should be permanent and perfect.
2. Of a wearable section replaceable when necessary.
3. In a macadam section it consists—

   (*a*) Of angular stones of varying size from a minimum to a maximum.
   (*b*) Of a material forming a matrix for the stones.

The Author also asserts that the road when originally made or after repair should be absolutely homogeneous, otherwise its lack of homogeneity leads to more rapid destruction.

Either you agree with this or you do not. If you do, you must agree that generally something needs to be done to better the surface of our macadamised roads. What exactly has to be done, and how, is for you to determine. There is a goal to be reached: there are materials to use in the details of the work in order to reach the goal. If one material is bad, try another.

DISCUSSION.

Mr. W. HARPUR: I have read this paper with very much interest and to some extent I agree with what the Author says. On other points I am not able to do so. I quite agree as to the necessity of a good foundation for a macadamised road; for, without a solid foundation, it is perfectly certain a good surface cannot possibly be maintained. Mr. Biggs says, once the foundation is laid it ought never to be tampered with. Now that is one of our chief difficulties. Unfortunately we can hardly finish a road five minutes before it has to be torn up for the laying down of gas or water pipes, electric lighting or telephone wires,

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drains or other purposes, and once torn up it is never restored to the same condition. That is the first and chief difficulty of keeping our roads in anything like a good condition in the towns, but it does not apply in the same degree to main county roads. I quite agree as to the matrix being of the same material as the road metal. I believe if a road is to have a surface which is expected to wear uniformly, the whole of the material used in its construction should be of the same character. Another difficulty we have is that of traffic during repairing operations. If a macadam road is to be made and left in the condition it should be, when being constructed the street or road should be closed to all traffic. But in my town the inhabitants would not tolerate the closing of a street or road when the surface is being re-coated, and we therefore have the traffic running over it while it is being made. Just assume a road being re-surfaced, and, between 5 o'clock in the evening and 6 o'clock the following morning when work has ceased, the traffic running uninterruptedly over the half rolled surface, resulting in a thousand stones being kicked out of place, and in the morning it is impossible to put them back again. It is in the spots where these stones are kicked out that the holes and undulations start, and the road begins to wear and become uneven. While the making of a road is in progress it should be allowed a day or two to consolidate and drain before the traffic is turned on it. Mr. Biggs says we should make our surface like a tramway track. The best and smoothest surface is an asphalt surface, and next to that a wood paved surface. But even with a wood surface and an asphalt surface we find the road does not wear uniformly. What kind of road surface is worse for wearing into holes than a wood paved road? yet the material is as near as possible of uniform quality and is laid, and with the greatest care, on a solid and even foundation. Then take an asphalt road. It is impossible to imagine any material for road purposes nearer Mr. Biggs's idea of perfection than asphalt, which can be prepared and placed together and compressed to an almost perfect surface. But even that material, when laid under the best possible conditions upon a solid and even foundation, does not wear uniformly. I have much pleasure in moving a very hearty vote of thanks to Mr. Biggs for his paper.

Mr. W. WEAVER: I beg to second the vote of thanks for this paper. It is very kind of a busy man like the Author to

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take the trouble to do this and to serve no purpose of his own. Still, at the same time I am too cautious to enter into the controversy to which we have been invited. When the Author states that the main function of a road is to afford traffic facilities, possibly many metropolitan surveyors will differ from him and define the main purpose of a road as furnishing a place for the laying of pipes. The question of traffic over it is quite a secondary consideration with all the various companies who have got money to spend and pipes to lay. Of course there are roads and roads, and their respective requirements vary with the districts and difficulties. In busy towns, and the metropolis especially, the circumstances are all against making perfect roads. You never start making a road of any length in the metropolis but you are stopped—somebody is going to be married, or buried, or born. Then the party who never gets to bed until one o'clock in the morning objects to your working early, and the man who goes to bed early objects to your working late. So if you are to adapt your work to the requirements of the various people living in the district, you have the greatest difficulty in continuing it at all. If automobile traction is to be the general mode of progression on roads in future, of course the roads will have to be changed and be adapted to the new type of locomotion. Then macadam will disappear, and with it the horse. Of course, asphalt, given the disappearance of the horse, is the best road surface, the smoothest and the most sanitary. At the same time it is a very expensive paving, and of course it is the duty of the municipal engineer to consider cost. There are a great number of people who have the greatest difficulty to find anything to live upon when they have paid their rates and made their houses sanitary. Now, if the refuse made in one direction can be utilised fully up to the hilt in another direction, then you get economy in municipal management. We have been able to make very good footpaths with our clinker refuse; in some districts you can make road foundations with it, or grind it up and make mortar; and in others, where the ratepayers are paying rates to build houses for the working classes, you may make bricks and build houses with it. You can make a very good clinker paving brick from your refuse. I passed my Whitsuntide in making experiments in this direction. The brick is composed of ground clinker refuse mixed with 10 per cent. of Trinidad asphalt and some flue dust, and then put under a

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pressure of 120 tons to the square inch. These paving bricks were made at the works of the Sanitary Block and Tile Paving Company. I have put these bricks down on a pull-up for omnibuses, and they have been down for a month, and if they can stand twelve months' wear I think they will prove sufficiently durable for secondary traffic roads. If a district can save the aunual outlay on wood paving by working up its house refuse clinker it will be a good thing and effect a great saving. If it is successful and if it brings down the rates 1½*d.* or 2*d.* in the pound it will be doubtless recognised in the usual way by the ratepayers, with thanks.

Mr. R. OAKDEN: The point which seems to have been most in the Author's mind was the difficulty of road construction having special regard to the matrix or binding material. Of course, that difficulty could be got over if you could use something of a true binding nature like tar. But the cost is too great to allow of the use of tar under ordinary circumstances. I should like to ask more experienced members if we are not making a mistake in insisting on having our material broken to a uniform gauge. If, instead of using all the stone broken to 2½ inches gauge and rejected by a 1¾-inch gauge, we were to use material containing all sizes from ¾-inch or 1 inch to 2½ inches, it would appear to me that we should have a less quantity of interspaces, require less binding material, and have less trouble with the roads.

Mr. A. E. COLLINS: The question raised by the last speaker is one of much importance in connection with road-making. I have laid material where the screening has been limited to the removal of dust, leaving in stone of from ⅜ of an inch up to 1¾ inches. And the smoothest road I ever laid was made with basalt macadam of these mixed sizes.

Mr. C. H. W. BIGGS in reply said: I do not know that I have very much to say. I might take the remarks of the last two speakers and mention this as a fact, that there are some road surveyors who absolutely refuse to receive metal broken to different gauges. Referring to Mr. Harpur's remarks, I had in my mind throughout the writing of these notes the progress of automobilism and the question of rolling friction entirely, rather than the kind of action that goes on in a road at the present time. If you have to do with nothing but rolling friction, you will find almost any road will retain its surface.

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At the present time you have horses trying to start on a road, digging in their feet and pulling up a stone, thus setting up a centre where everything that goes across increases the damage. I do not think I have anything to add except to point out to you who live in particular districts that on the Continent a good deal of blast furnace slag is used for making roads. Mr. Weaver is using clinker from his refuse destructor to make bricks to pave some of his roads. On the Continent they are using slag not only for the roads but for the building of houses. I should be glad to see more clinker used on roads where the traffic is not very heavy.

The PRESIDENT: Furnace slag was used in Bristol and had to be given up because the material was so brittle.

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FLOODS PREVENTION WORKS IN BRISTOL.

By W. J. STEELE, Assoc. M. Inst. C.E.,
Deputy City Engineer.

The prevention of flooding in Bristol has been a source of anxious thought to the City Council for several years, and whilst much has been done to alleviate the danger, it cannot perhaps be claimed that the task is completed; consequently the question is still under consideration at more or less frequent intervals.

The Corporation are Conservators of the Port and Harbour of Bristol extending from Hanham Mills on the river Avon to the mouth of such river at King's Road, a distance of about 14 miles, and thence down the river Severn and the Bristol Channel from King's Road westward, to the islands called the Stipe or Steep Holmes and the Flat Holmes, an additional distance of about 20 miles; and are also conservators of the rivers and brooks within the port, all of which are under the control of the Docks Engineer, Mr. W. W. Squire, M. Inst. C.E.

The city proper is about 5½ miles from the mouth of the river Avon, and is 11,607 acres in area.

The physical character of the district, which is at the lower end of the Avon valley, is somewhat hilly, the city forming a basin, the general level of whose perimeter is about 240 feet above the Ordnance Datum, and whose centre is about 27 feet above such Datum.

The floating harbour, formed by the conversion into docks of parts of the rivers Avon and Frome, is immediately northward of the present course of the Avon. The entrance to the harbour is about 7 miles above the mouth of the river Avon, and at the northern and upper end of one arm of the harbour is the principal of the outlets of the river Frome, the second

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being by the arched waterway known as the Castle Ditch which branches off the Frome about ¾ mile above the first outlet, and, by a circuitous course 450 yards in length, reaches another arm of the harbour. When the harbour was formed, an overflow, known as Mylne's Culvert, was constructed from a point in the Frome about 270 yards above its principal outlet to the river Avon, thus forming a third outfall.

About 5¼ miles upstream from the head of the harbour, the river Frome enters the city and flows in an open course for a distance of about 4½ miles to a point known as the Tunnel-head, and from this point to its mouth, a distance of about 1600 yards, it is arched over. At a distance of 200 yards above the Tunnel-head is the inlet to an arched waterway known as the Back Ditch, which runs nearly parallel with the main course of the Frome for a length of 650 yards, when it joins the Frome archway. There is a connection between the Frome and the Back Ditch by means of an overflow culvert about midway in the length of the latter.

At a distance of about 1½ miles from its mouth, the river Frome receives the Cutlers Mills brook, which in turn receives the Boiling Wells stream. These two waterways will be described later. Within the city there are nine bridges and one railway viaduct over the Frome, and before the improvement works were carried out, some of these were important causes of flooding from that river.

On the southern side of the river Avon, the Malago brook, having a catchment area of 2650 acres, flows through the city for a distance of about 2 miles and had two outlets into the river Avon 460 yards apart. The eastern arm is 570 yards in length, at the head of which it is joined by the western arm, which is 680 yards in length; there is an overflow culvert from the western to the eastern arm 120 yards in length, about 140 yards northward of the junction of the two.

The flooding which has taken place in the city, has been in areas thickly populated, and has been principally caused by the waterways named, viz.: the river Frome, Cutlers Mills brook, Boiling Well stream and the Malago brook, very large areas being submerged in 1869, 1882 and 1889, whilst in 1894 and 1900 some slight flooding again occurred.

As before mentioned, the entrance to the floating harbour is from the river Avon, which is subject to an exceptionally high

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range of tides—during ordinary spring tides a rise and fall of 40 feet occurring—and the time of high water is frequently maintained beyond the natural period by the fresh brought down the river. This will be understood when it is said that over sixty million cubic feet per hour have been discharged at the mouth of the Avon, whose dry-weather discharge is not more than 250,000 cubic feet an hour. The normal level of the floating harbour is 19·78 feet above Ordnance Datum, and is governed by sluices fixed near the Docks Engineer's offices in Underfall Yard, about $\frac{3}{8}$-mile above the harbour entrance. As the level of the Avon is frequently above that of the harbour at H. W. O. S. T. during heavy rainfalls, the sluices cannot be opened until such time as the tide will permit, a period of two hours having frequently occurred during which they were closed; consequently the harbour acts as a storage reservoir for the waters of the Frome when the sluices are closed, and in order to provide sufficient capacity during and immediately after a heavy rainfall, the normal level of the harbour is lowered before high water. It will be seen that considerable judgment is required to adjust the level, because if lowered too much the shipping would be in danger; on the other hand, if not lowered enough, the low-lying property may be flooded from the harbour itself; and to assist him, the Docks Engineer has telephonic communications from gauging stations, of the heights of the Frome at various points on its course. One of these stations at Frampton Cottrell, is about seven miles above the floating harbour, so that a rise on the gauge can be anticipated about an hour and a half before such rise affects the lower reaches, as the velocity in high flood does not exceed 5 miles an hour. Owing, however, to the numerous tributaries between the harbour and Frampton Cottrell, it is necessary to have this warning supplemented by those from other stations.

The area of the floating harbour is about 83 acres, and it has been thought that a safe range of level is 4 feet—that is from 2 feet below normal level to 2 feet above—so that a storage capacity of 15 million cubic feet is available; therefore the margin of safety of storage capacity, should spring tides be accompanied by a south-westerly gale during a heavy rainfall, is not very high.

The catchment area of the river Frome is 68 square miles, 1 inch of rainfall producing 158 million cubic feet an hour; and

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in a report on the subject by Mr. Francis Fox, M. Inst. C.E., in 1889, he estimated that a rainfall of 3 inches in twenty-four hours would give 300 million cubic feet an hour after a liberal allowance for evaporation and absorption. That this is not an improbable rainfall will be seen from the following:

In August, 1865, 2·90 inches fell in fifteen hours, of which about 2¼ inches fell in four hours.

In June 1884, 2·40 inches fell in ten and a half hours.

In October 1882, 3·30 inches fell in eighty-four hours, of which 2½ inches fell in thirty-six hours.

In March 1889, 3 inches fell in forty-eight hours, of which 1½ inches fell in eight hours.

In November 1894, 2·40 inches fell in forty hours, of which 1·4 inches fell in twelve hours.

In February 1900, ·95 inch fell in twelve hours after a heavy snowfall.

In December 1900, 1·68 inches fell in eighteen hours.

It may be interesting to notice the effect on the river Frome and floating harbour of some of these rainfalls. On November 12, 1894, rain stopped at 4 p.m. and during the previous forty hours 2·40 inches fell, of which 1·40 inches fell in twelve hours, previous to 1.30 p.m. on the 12th; the Frome rose to 7 feet 1 inch above normal harbour level at 2 p.m. and at 9 p.m. it was 10 feet 8 inches above. In the afternoon on the date mentioned, the floating harbour was lowered 2 feet below normal level, the sluices were closed at 5.27 p.m. and were opened at 7.7 p.m., a period of one hour and forty minutes; the greatest height to which it rose was 2 feet above normal level at 7.15 p.m.

On December 31, 1900, when 1·68 inches of rain fell in eighteen hours before 4 a.m., the Frome rose to 11 feet 3 inches above normal harbour level at 9 a.m., and discharged for a period of three hours, 9 million cubic feet per hour; owing to neap tides being prevalent, the flood water in the harbour ran through the sluices as fast as it came down.

Numerous reports have been made on the prevention of flooding, and several of the various works recommended have been carried out, of which the following is an epitome.

In January 1881, Mr. T. Howard, M. Inst. C.E., the Docks Engineer, recommended pumping power being provided to deal with flood water in the floating harbour.

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In April 1882, Mr. Robert Rawlinson, and Mr. H. J. Marten, M.M. Inst. C.E., suggested the propriety of making a relief culvert or tunnel from the river Frome at Stapleton to the river Avon at Durdham Downs, a distance of about 3¼ miles.

In May 1883, Mr. Howard again reported in special relation to the great flood of October 1882, which attained its maximum height about 10 p.m. on the 24th of that month. He estimated the quantity of water ponded in the flooded district within and above the city boundary at about 27 million cubic feet, and the area covered by flood to be 125 acres, and discussed the advisability of constructing a storage reservoir in the Frome valley to impound the surplus water, but thought the most effectual way would be to tap the Frome at some point above the city, and carry off part of the flood water direct to the Avon.

The Bristol (River Frome) Act was obtained in 1887, by which power was granted to construct certain works, of which the following were carried out: a relief culvert 156 yards in length, 12 feet wide and 7 feet 6 inches high, from the river Frome at a point about 1200 yards above its mouth, to the floating harbour; the waterway was widened and deepened at various points, involving several retaining walls; a bridge was rebuilt with increased span; an ancient archway was reconstructed; new sluices were provided in the floating harbour, and several sewers were diverted. These works were completed in 1890 at a cost of 42,779*l.*, the purchase of property and other rights amounting to 9846*l.*

In May and August 1889, Mr. Francis Fox said there were three methods open to adoption for the permanent prevention of floods from the river Frome within the city, either separately or in more or less of combination. (1) The improvement of the existing channel; (2) the construction of five storage reservoirs at and above Stapleton; (3) the construction of a relief culvert to the river Avon. He recommended the enlarging of a portion of the arched waterway; the widening and deepening of the open waterway in places; the reconstruction of three bridges; and the construction of the relief culvert, 20 feet wide by 14 feet high, to the Avon; at a total estimated cost of 165,000*l.* Mr. Fox was of opinion that the Frome in its improved state would discharge without flooding 6 million cubic feet an hour, any surplus being conveyed by the suggested culvert which would be of sufficient capacity to convey another 6 million cubic feet. For

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the purpose of distinction, it may be added that the last-named proposal became known as the Black Rock culvert.

In July 1889, Mr. Fox reported on the flooding and its prevention from the Malago brook, and recommended that the bed of the brook should be excavated to a uniform gradient. He recommended also the reconstruction of the western outlet culvert for a length of 170 yards, the construction of a parallel culvert 140 yards in length from the head of the eastern outlet to a point 140 yards down stream, the construction of a loop culvert about 120 yards in length parallel to that existing 130 yards southward of the junction of the two outlets, and a culvert 10 feet by 8 feet from a point near St. John's cemetery to the river Avon, a distance of 1300 yards, giving a third outlet about 780 yards westward of the existing west outlet.

The Bristol Floods Prevention Act, 1890, was obtained to improve the channel of the Frome, to construct the Black Rock culvert, and to make improvements in the Malago brook.

Before using the powers conferred by the above Act, Sir John Coode was asked to report on the subject, which he did in February 1892, when he said that the proposed Black Rock culvert was necessary to *entirely* prevent flooding from the river Frome during periods of excessive rainfall when coupled with adverse conditions of tides.

With the exception of the Black Rock culvert, the works comprised in the Act have been carried out at a total cost of 61,139*l.* The works in the Frome cost 28,439*l.*, of which 5628*l.* was for purchase of property and other rights, and the works in the Malago 32,700*l.* of which 5369*l.* was for property and rights In February 1893, the Council decided that no further steps be taken in respect to the culvert until the other relief works had been completed and reasonable opportunity given for testing the same.

In March 1895, Mr. J. M. McCurrich, M.A., M.Inst.C.E., the Docks Engineer, in referring to the flood of the previous November, stated that no opportunity of testing had occurred until the latter month, when it was found that the velocity of discharge of the Frome had been greatly increased, and that consequently its capacity was higher than the previously estimated discharge of 6 million cubic feet an hour, he being of opinion that the maximum discharge on November 12, 1894, was about 9 million cubic feet an hour, the river having risen higher

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than calculated upon. Mr. McCurrich thought that a relief culvert to convey 3 million cubic feet an hour would be sufficient to relieve the improved channel of the Frome, but a discharge of 9 million cubic feet an hour was too much for the floating harbour to store; and he recommended that a pumping station be erected near Cumberland basin with eight 57-inch centrifugal pumps, and, as an alternative to the suggested Black Rock culvert, that a reservoir be constructed below Stapleton to take any surplus over 9 million cubic feet an hour, so as to prevent the overflowing of the Frome, with a capacity of 20 million cubic feet. These works were estimated to cost 80,000*l*.

In December 1894, Mr. T. H. Yabbicom, M. Inst. C.E., the City Engineer, reported upon the flooding caused by Cutlers Mills brook. As the works recommended in that report were only completed in May last, they will be described in more detail than the others.

The brook rises southward of Henleaze Park at a point 600 yards inside the northern boundary of the city, and is an open watercourse for a distance of 1400 yards; it then runs in a 4 feet by 3 feet 6 inch culvert for a distance of 230 yards, which joins the portion of the brook culverted by the Great Western Railway under their Clifton Extension Viaduct and Station Approach Road. About 20 yards above this junction is the head of the railway culvert, where three small culverts and a sewer storm-overflow, converge; one of these culverts receives the local storm-water from an adjoining road, one acts as a relief to the 4 feet by 3 feet 6 inch culvert named above, and the other receives the storm water from a portion of the district of Horfield immediately northward of the above railway. The railway culvert is 143 yards in length, from the lower end of which the brook runs in an easterly direction for a distance of 1650 yards, where it discharges into the river Frome; of this distance about 650 yards has been arched over by the owners of property abutting on the brook, in various forms, with the result that during a heavy rainfall this arching has burst and caused severe flooding in the vicinity.

In the public park in Mina Road, the brook is joined by the Boiling Wells stream, the flooding from which formed the subject of another report described later. In 1896, the City Council promoted a Parliamentary Bill for power to carry out works in connection with the Cutlers Mills brook and the Boiling Wells

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stream, but at the formal "Town's Meeting" a poll was demanded, the result of which was unfavourable, and the Bill was dropped.

In 1899, the Bristol Floods Prevention Act, 1899, was obtained, granting power to construct the Cutlers Mills brook relief culvert.

The catchment area of the brook is 900 acres, and the storm-water from a large and increasing proportion of this area is drained from the practically impervious surface of roads by sewers directly into the brook. Moreover, the district is somewhat hilly, the difference in level between Zetland Road and the source of the brook being 100 feet, and the distance only 1500 yards. It is estimated that a rainfall of 3 inches in 24 hours will produce 400,000 cubic feet an hour, after deducting a percentage for evaporation and absorption, which is only small in such a district. With such a contracted and precipitous drainage area, which is rapidly being covered by buildings, it was necessary to make provision for a rainfall of greater intensity than that named above, and Mr. Yabbicom recommended the construction of a relief culvert commencing at the lower end of the railway culvert and running in a southerly direction and nearly a straight line, to the Back Ditch of the river Frome.

The culvert is 1367 yards in length, of which 780 yards is under private lands and buildings; from the Back Ditch for a distance of 485 yards, it is 7 feet in diameter with a gradient of 1 in 467; from this point it is 6 feet in diameter with a gradient of 1 in 60 for a distance of 550 yards, and 1 in 46 for the remaining length of 332 yards, the capacity of discharge being 1,156,800 cubic feet an hour.

The Back Ditch is of masonry 10 feet 6 inches by 7 feet 3 inches, with battered side walls and a segmental arch having 1 foot 6 inches rise, but has no invert. At the junction of the new culvert with the Back Ditch, the centre lines of the two include an angle of 77°, and the connection is made on a curve of 27 feet 6 inches radius. Owing to the impracticability of joining the new brickwork of the culvert with the defective masonry of the ditch, the latter was removed for a length of 34 feet and rebuilt in brickwork to the same section, the ends being tongued into the old work. As of course the circular culvert could not directly join another of quite different section, the former section was stopped near the beginning of the curve

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and then formed with vertical side walls and segmental invert and arch, the skewbacks of the latter being pennant stone springers notched on the springing face to receive the sweeping courses of brickwork, thereby preventing any cutting of bricks, and ensuring stability in an arch whose maximum span is 19 feet and whose crown is only 2 feet 9 inches below the surface of the road carrying heavy traffic. From this junction the culvert was in open cutting for a distance of 221 yards, 163 yards being in made ground and 58 yards in red sandstone; the remaining portion of the 7 feet section was in tunnel through hard red marl and sandstone. From the end of this section the 6 feet culvert commenced and was in tunnel for a length of 819 yards, 550 of which was in red sandstone and 269 in blue lias and soft marl; the remainder of the 6 feet section was in open cutting through soft marl.

Parallel to the culvert at a distance of 18 inches, and at an average height of 3 feet 6 inches above the invert, an old masonry sewer 3 feet 6 inches by 3 feet runs for a length of 330 yards, and when this was charged, some little difficulty was experienced in keeping the new work dry, but this was got over by building small iron pipes into the brickwork as it proceeded, and afterwards plugging the ends. Connected to this sewer was one of masonry 4 feet 6 inches by 2 feet 6 inches from a road at right angles to the line of culvert and 2 feet 6 inches below the soffit of the new work; this latter sewer was destroyed and replaced by another to fall in an opposite direction to a different outfall.

The greatest number of sections in progress at one time was nine, two faces being worked at the same period from each shaft where the work was in tunnel, and the greatest length between such shafts was 807 feet; for a length of 26 feet, the culvert passes under large vats of a jam factory, and though the crown of the arch was only 9 feet below the surface of the ground and 3 feet below the bottom of the vats, this length was constructed in tunnel so as to avoid heavy compensation to the owner of the factory.

All the sandstone and hard marl was first broken by explosives, with comparatively small damage to the surrounding property; gelignite was used in tunnel and black powder in open cutting, ratchet drills being used for the firing holes, which were one inch in diameter and 2 feet 6 inches in depth. The

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course of the old culvert crossed the line of the new work near the head of the latter, and during construction, a temporary heading, 5 feet 6 inches by 3 feet 6 inches, lined with sheeting and having a brick dam at its inlet, was driven for a length of 40 feet; this heading ran full on four occasions without damaging the new work.

The contractor, Mr. Edmund Nuttall, of Manchester, commenced the work on April 1, 1901, and the water of the brook was turned into the culvert on May 26, 1902, or about four months before the end of the contract time. Mr. L. S. McKenzie, Assoc. M. Inst. C.E., acted as Resident Engineer and Mr. T. W. Edwards as Clerk of Works. All claims for easements and other rights have not been settled, but the contract sum was 21,546*l.* and the total cost, including all easements, compensation and other charges, will be about 28,000*l.*

In March, 1895, Mr. Yabbicom reported upon the flooding caused by the Boiling Wells stream, which has its origin near the northern boundary of the city where this crosses the South Wales Branch of the Great Western Railway and drains the valley between the districts of Horfield and Stapleton, and also receives the overflow from the "Boiling Well" under Ashley Hill (a copious spring belonging to the Waterworks Company), and finally discharges into Cutlers Mills brook.

The stream flows through private lands in an open channel for a distance of 1¼ miles, and is culverted for the remainder of its length, viz.—420 yards, three times under the railway and once under houses, whilst two mill streams are formed off it. The causes of the flooding have been that one of the culverts under the railway and that under the houses are too small to carry off the flood water in heavy rainfall, the defective state of the bank of the mill-streams and its overflows, and to certain unnecessary weirs in the stream itself, some of which have recently been removed.

The estimated cost of the relief works, including compensation for easements, was 25,000*l.*, but nothing has been done to carry out these proposals since the Parliamentary Bill was promoted in 1896 and rejected by the poll of the inhabitants, the Council deeming it advisable to await the effect of the works in connection with Cutlers Mills brook.

In July, 1901, the Docks Engineer and the City Engineer submitted a joint report for improving the overflow from the

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river Frome to the Castle Ditch under Broad Weir, the surplus water from the Frome having at present an awkward angle to pass in order to get into Castle Ditch; and they recommended that a culvert 5 feet in diameter and 50 yards in length be constructed between the two waterways in a curve so as to admit of a better flow, at an estimated cost of 1250*l.* including compensation; this work is now in progress.

During the last fourteen years the Council have spent over 132,000*l.* in works of flood prevention, so that it will be seen the question has been treated in an earnest manner and with considerable success, since the former disastrous effects of heavy rainfalls have been very greatly reduced, as shown by the fact that in 1894 and 1900 very small areas were flooded—and these by the Cutlers Mills brook and Boiling Wells stream—although the rainfall was nearly equal to that in 1882 and 1889, when large and densely populated areas were submerged, causing widespread loss and suffering.

In submitting these notes to the Association, the Author desires to acknowledge the assistance he has received from the Docks Engineer and his River Inspector, Mr. W. H. B. Reed.

DISCUSSION.

Mr. V. Smith: I beg to move that the best thanks of this meeting be given to Mr. Steele for his interesting paper. As an old Bristolian, I feel very great interest in this matter. I regret very much that although the Council gave proper consideration to your complete scheme of flood prevention, the ratepayers did not give the same consideration to it, but when a poll was demanded, rejected it. Some of us who know the city and have seen it under flood, and been across the Broadmead and other streets in the centre of the city in boats, know what a great amount of work has been done and the great amount of time and money spent in preventing floods. I trust that the culvert suggested will be made. When it is done it will be realised what a mistake was made in rejecting the scheme at the town's meeting. I do not think since 1889 there have been anything like the floods the city had in the early part of that year, and I hope the city will not have anything of the kind

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again. I am sure if the culvert was constructed as proposed from Stapleton to Black Rocks that would meet the difficulty and prevent the scenes which used to occur some years ago in the flooded area.

Mr. W. H. GRIEVES: I have pleasure in seconding the vote of thanks. It is a paper we cannot very well criticise, because only those on the ground can know what is required to be done in a case like this. I have listened with very great interest to the paper.

Mr. C. F. WIKE: With reference to wayleaves, it would be rather interesting to know how that question was settled. It must have been rather an expensive thing.

The PRESIDENT: You never know what may happen in Bristol with heavy rainfall, accompanied by high tides and westerly gales. In the heavy rainfall of 1894 the result was very encouraging. Previous to that time I recollect that the streets of Bristol were invaded with floods on several occasions, people having to cross from one street to another in boats. At Stapleton Road especially the water has at times been several feet deep. After these floods prevention works were carried out, the late docks engineer and myself were during heavy rainfall at one period of 1894 anxiously watching the rise of the water in the Frome at a place called Ashley Road, where one of the new bridges had been constructed. While the water was rising we stood and watched it go up in a few minutes 3 inches, then 6 inches, then a foot, and when at length the crest of the wave overlapped the under side of the girder our hearts went into our boots; but to our relief that was the highest point, and the water rapidly sank. That experience encourages one to think that the work which has been done has had a very good effect.

Mr. STEELE, in reply said: The question of wayleaves did give some rather anxious thought. Before commencing the work the corporation purchased any building under which the culvert would pass, where the cover was small. Where the crown of the culvert was of greater depth than 12 feet easement only was purchased, but where it was less the property was bought outright. Now the work is finished the corporation is selling the property. The total cost of the easement will amount to about 3400*l.* or 49*s.* 9*d.* per yard run of the whole work.

The PRESIDENT: The work was done under a special Act of Parliament.

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DESCRIPTION OF PROPOSED EXTENSIONS AT THE INFECTIOUS DISEASES HOSPITAL OF THE CORPORATION OF BRISTOL, AT HAM GREEN.

By HERBERT W. HARDING, Chief Architectural and Engineering Assistant to the City Engineer.

Three years ago the Corporation of Bristol opened their hospital at Ham Green, but it was soon found that the accommodation provided was inadequate to meet the requirements of the extended city, and it was resolved to erect additional buildings on the same site. It is the purpose of this paper to briefly describe the proposed additional works.

The accommodation to be provided includes—

Two-story pavilion.
Observation pavilion.
Discharging block.
Additional wing to the original administration building.
Water storage tank and tower.

Two-Story Pavilion.

This building has been designed to accommodate fifty beds, and is to be erected upon a piece of ground to the west of the present pavilions.

The chief point in which the new pavilion differs from those already erected is that, in addition to containing a larger number of beds, the wards have been arranged on two floors thus economising space, and reducing the cost by saving the duplication of foundations, roofs, drains, and hot and cold water supply.

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This is fully exemplified by a comparison of the cost per bed, the one-story pavilion costing 296*l.* per bed, and the two-story pavilion costing 246*l.* per bed, thus showing a saving of 50*l.* per bed.

The new building has been designed to correspond with the original ones as regards style, and is to be built in red pressed Cattybrook facing bricks, with dressings of box ground stone.

The external walls are to be built hollow, with a 9-inch inner and outer wall and a 3-inch cavity, these walls being tied together with Stanley's salt-glazed bonding bricks.

The damp course used is of Callender's pure bitumen sheeting.

The roof is boarded, felted and covered with Port Madoc slates.

On entering the building on the ground floor, and passing through the vestibule, the central hall is reached, out of which all the other rooms open.

To the north and south are the wards for males and females respectively, each containing twelve beds; they are 72 feet long, 26 feet wide and 13 feet high, giving a cubic space per bed of 2028 feet.

In the east wing is situated the nurses' duty room, with inspection windows, which enable the nurses to supervise the wards.

In the west wing is a one-bed ward, 13 feet by 12 feet by 13 feet; linen-room, 12 feet 6 inches by 6 feet; coal store, 12 feet 6 inches by 6 feet; pantry, 12 feet 6 inches by 6 feet.

Adjoining the north and south wards, and separated therefrom by an air passage 4 feet wide, are the offices, containing bath room, 11 feet 6 inches by 9 feet, lavatory, two w.c.'s, and slop sink.

The wards and offices on the first floor are similar to those already described on the ground floor, but the floors are completely isolated from each other, the upper one being approached by a stone staircase, 5 feet wide, situated on the right hand side of the principal entrance.

The floors throughout the building, with the exception of offices and vestibule, are constructed of cement concrete, 7 inches in thickness, carried on rolled steel joists, the top surface floated over with 1 inch of Portland cement, and laid with 1¼-inch wrought, grooved and tongued pitch-pine batten flooring, beeswax polished, in 3½-inch widths, set in mastic and secured with

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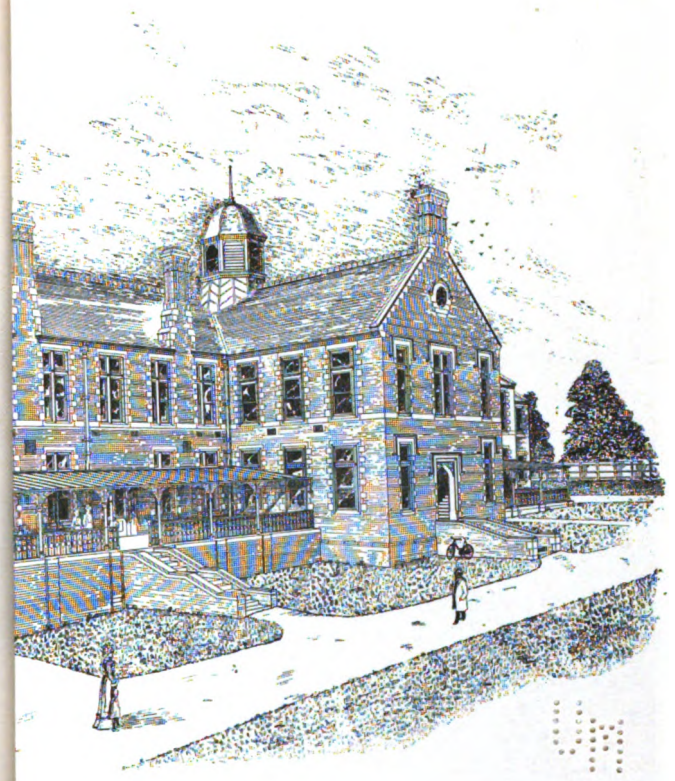
PLATE I.



L: PROPOSED WARD PAVILION.

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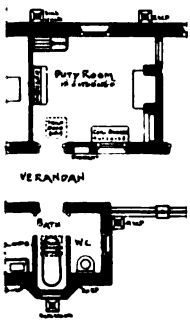

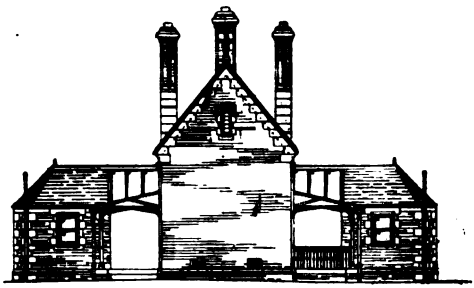

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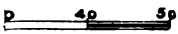

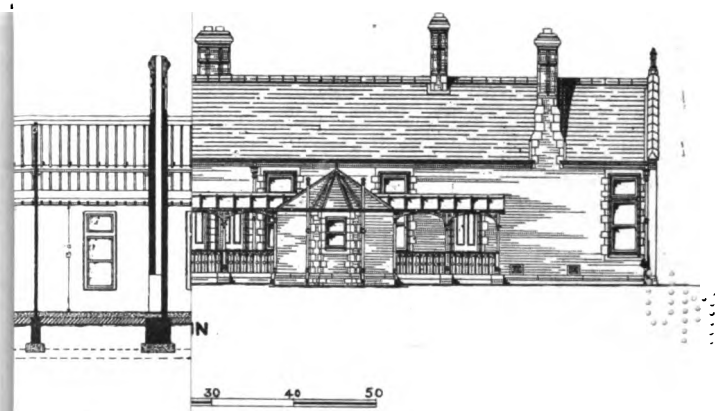

HAM

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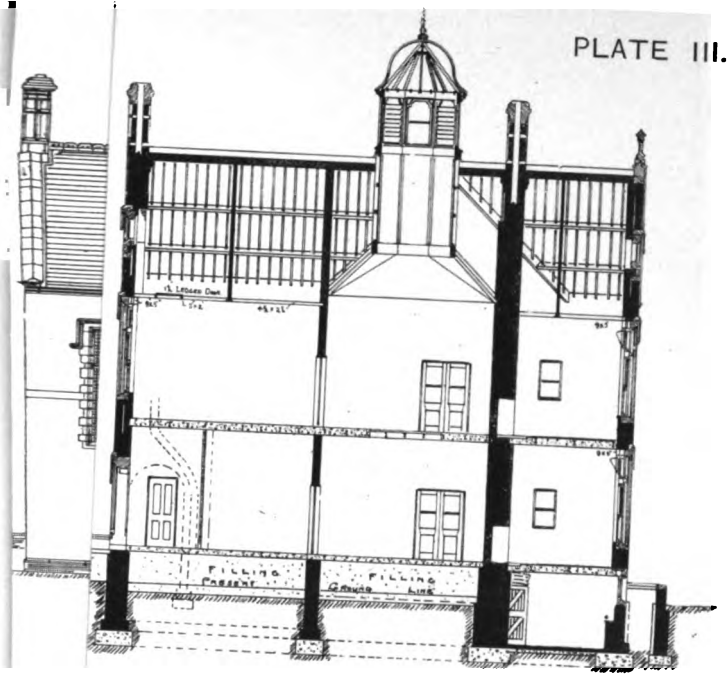
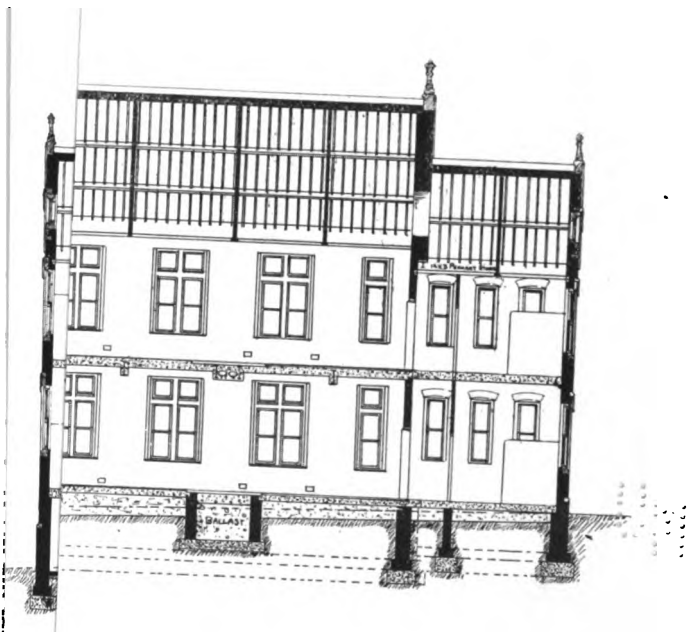
PLATE III.



SECTION CC.



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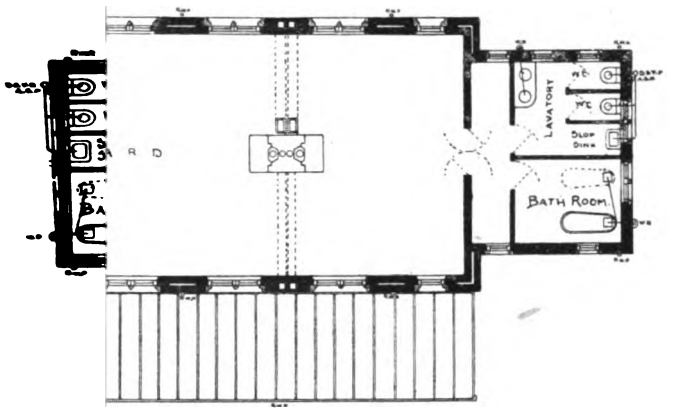

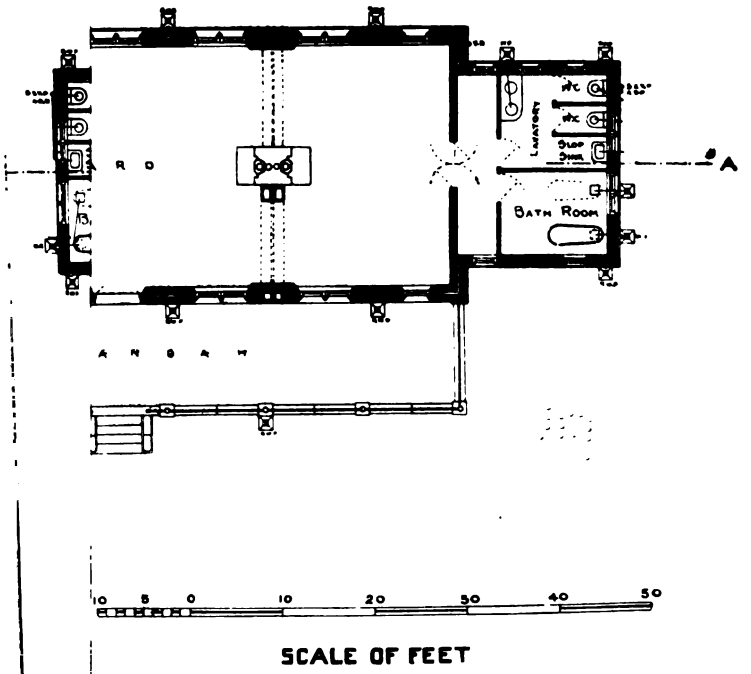

SCALE OF FEET

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oak tongues, and secret nailed to 2-inch by 1-inch dove-tailed bearers, 2 feet centres, set in the cement floating.

The floors to offices are laid with granite-faced cement concrete paving, laid *in situ*, and that of the vestibule with encaustic tiles.

The walls and ceilings, with the exception of offices, are plastered in Keene's cement, all corners and angles being rounded to prevent lodgment or accumulation of dust. The ceilings and fillings to walls are painted in a cream tint with green dado and red stencil border. The walls to offices are lined with white-glazed bricks.

The windows to the wards below transom are double-hung sliding sashes, with deep ventilating sills, and above transom hinged casements to fall inwards, with wrought-iron glazed side-cheeks, and fitted with Leggots' openers to enable the lights to be adjusted for ventilation as may be required.

In addition to the window ventilation, an inlet panel ventilator, with movable front, is placed beneath each bed.

Each ward is warmed by two of Shorland's ventilating double-fronted Manchester open-fire stoves, with tile sides; the flue and ventilating pipes are carried under the floors to chimney-breasts on side-walls, and are constructed of oval fireclay pipes bedded in concrete, supported by steel joists; doors for cleansing purposes are placed in the floors and breasts. Fresh air is carried direct to the stoves by means of similar pipes, and in the course of its circulation through the stoves it becomes warmed before passing into the wards.

The warming of the wards is supplemented by low-pressure hot water radiators placed under the windows. Provision is also made for warming linen-room, central hall, corridor, bath-rooms, and offices by hot water pipes and radiators, the boiler being placed in heating chamber in basement.

The building is artifically lighted throughout by electricity, generated in the station on the site. The wiring is carried out upon the eight-amperes system, and the lights are controlled from a switchboard placed in the central hall.

On the west side of the north and south wards on the ground floor are verandas 12 feet wide running the entire length of same, with double doors opening direct from the wards, affording facility for patients' beds to be moved out in suitable weather. The verandas are constructed of ornamental cast-iron columns,

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brackets and railings, and covered in with Helliwell's patent glazing and rough rolled glass.

In consequence of the fall in the ground a basement has been formed under the north ward, which is to be utilised as a coal store.

In the well of staircase a lift is provided for taking coal to and removing soiled linen, etc., from upper floor.

The central hall on first floor is lighted from above by a turret, which forms an important architectural feature of the building, and the rays of light, entering and falling upon a pavement light fixed in the floor, pass through to the hall below. In each hall a fire-hydrant is provided, with two lengths of hose, fitted with Morris's instantaneous self-locking couplings and delivery pipes.

Each duty room contains a cooking-range, dresser, and porcelain enamelled fire-clay wash-up sink, with teak drainer and hot and cold water valves.

The hot water supply is provided by means of a dome top boiler placed in the heating chamber, with flow and return pipes carried to cisterns in roof. To ensure a quick supply of hot water to the bath-room, circulating pipes are fixed above the ceilings to the extreme ends of the building.

The bath-rooms are provided with cast-iron porcelain enamelled baths with rolled edges.

Observation Pavilion.

This is to be erected on the west of the principal entrance for the reception of cases requiring special observation, to enable the medical officer to properly diagnose a case before drafting it into the fever pavilion.

It will also be found useful for nursing isolated cases, thus saving the necessity of devoting a large pavilion to this purpose.

The building accommodates eight beds, and is divided into two sections, for males and females respectively, each section being isolated from the other, with separate entrances facing east and west, and containing two one-bed wards, 13 feet by 12 feet by 13 feet, and one two-bed ward 24 feet by 13 feet by 13 feet. A nurses' duty room, 15 feet by 13 feet by 13 feet, fitted with small cooking-range, wash-up sink, dresser, linen-cupboard with hot water coils for airing linen, and coal-bunker.

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Each ward opens direct on to a veranda, 40 feet long and 8 feet wide. The offices are detached from the wards, but are easily accessible by crossing the verandah, and comprise a w.c., slop-closet and bath-house for filling and discharging movable bath. The general design and construction of the building resemble that of the pavilion before described.

Discharging Block.

On the east side of the principal entrance, and in the vicinity of the porter's lodge, is to be erected a bathing and discharging block through which all patients will pass before leaving the hospital. The building contains a waiting-room, 12 feet by 7 feet 6 inches, for the accommodation of relations and friends meeting discharged patients, undressing room, bath-room, dressing room, w.c. and vestibule.

The bath-room is fitted with a cast-iron porcelain enamelled bath with hot and cold water valves and lavatory basin, and the floor is paved with red tiles.

Additional Wing to Administration Building.

In order to provide additional accommodation for the staff, a wing is to be built on the west side of the administration building, containing upon the ground floor a work-room, store-room, nurses' lavatory, w.c., cooks' pantry, stationery cupboard, four dormitories for servants, 17 feet by 13 feet, each containing three beds, one single bedroom, bath-room, and w.c. On the first floor there are thirteen bedrooms, 13 feet 4 inches by 8 feet 3 inches, for nurses, bath-room and w.c.

Water Storage Tank and Tower.

The water storage tank and tower is to be erected in the gardens adjoining the site.

The tower will be 45 feet high from ground level to under-side of tank, constructed of No. 16 cast-iron columns, 10 inches diameter, $\frac{7}{8}$-inch metal, each built up in three sections, with flanged spigot and socket turned and bored joints; the flanges being bolted together with four $\frac{7}{8}$-inch bolts.

The lower section will have a base-plate cast on 2 feet

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6 inch by 2 feet 6 inch by 1¼-inch metal, resting on a pennant padstone 3 feet by 3 feet by 9 inches, with a cushion of lead inserted between the plate and padstone.

The centre columns have foundations of Portland cement concrete 6 feet by 6 feet by 6 feet 6 inches, and the outside columns 4 feet by 4 feet by 4 feet 6 inches.

The columns are to be bolted down to the foundations with four 1½-inch bolts secured to two 2 feet 3 inch by 4 inch by ½ inch iron plates embedded in the concrete. The intermediate girders are of cast iron 9 inch by 4 inch by ⅜-inch metal with ornamental perforated webs, bolted to flanges of columns by ¾-inch bolts. The columns are braced with 1¼-inch steel rods with forged and forked ends secured with 1-inch bolts to lugs cast on columns.

The floor upon which the tank rests is constructed of rolled steel joists, principal joists 10 by 5 inches, intermediate joists 5 by 4 3/16 inches, minor joists 4¾ by 1¾ inches, riveted up with angle iron plates and cleats and secured to heads of columns with ¾-inch bolts.

The tower is surmounted by a cast-iron tank 30 feet by 30 feet by 6 feet, capacity 30,000 gallons. The bottom plates are 3 feet 4 inches by 3 feet 4 inches, and the side-plates 6 feet by 3 feet 4 inches by ⅝-inch metal, with stiffeners, ¾-inch flanges and ⅝-inch feathers. The flanges are on the outside and have planed joints, with ½-inch caulking space on the inside 1½ inch deep, the joints being made with sal-ammoniac and steel filings. The flanges are bolted together with ¾-inch bolts.

The tank is internally stayed with ⅞-inch tie-rods and covered in with corrugated galvanised iron roofing.

The supply to tank is by a 3-inch pipe from the Portishead Water Company's mains.

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DISCUSSION.

Mr. W. HARPUR: It gives me great pleasure to move a vote of thanks to the Author, who has given us a very graphic description of these hospital buildings, and which are very instructive to those about erecting such an institution.

Mr. A. E. COLLINS: In seconding the vote of thanks I should like to ask if the Local Government Board raise any objection to this double-decker pavilion. We tried to get plans passed for a doubled-decked hospital, but they would not sanction it.

The PRESIDENT: I have already mentioned this in my paper on Twenty-five years of Municipal Progress in Bristol.

Mr. J. F. SMILLIE: asked whether the hospital was for the treatment of more than one form of infectious disease.

Mr. H. SHAW: There is just one question I should like to ask in regard to the discharging block. What diseases are treated in this hospital, including the old and new portions of the building, scarlatina, typhoid and diphtheria? If so, was any objection raised by the Local Government Board to the provision of only one suite of rooms for discharging patients. We have recently had to put in two separate discharging rooms to our infectious hospital, because we treat scarlet and typhoid fevers.

Mr. HARDING, in reply said: We had no difficulty with the Local Government Board as regards the discharging block. They allow the discharge there of all patients nursed in the hospital. Of course the majority of cases are scarlet fever, but in the case of typhoid and diphtheria, the bathroom and other rooms would be disinfected before a patient who had had any other disease would be passed through the block. We had no objection raised by the Local Government Board.

The PRESIDENT: I mentioned yesterday that no small-pox is treated at Ham Green, but that all small-pox patients are treated at another hospital at Nover's Hill three miles distant. Having to provide two sites for infectious hospitals was a great expense to the city, but was wisely insisted on by the Local Government Board.

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THE BRISTOL TRAMWAYS ELECTRICAL INSTALLATION.

By J. CLIFTON ROBINSON, Assoc. Inst. C.E., M.I.E.E.

One of the first companies in Great Britain to recognise the advantages of electric traction and to adopt it for its tramway system was the Bristol Tramways and Carriage Company, Limited.

In anticipation of the Board of Trade Regulations of 1894, plans were prepared, and in October, 1895, the first Power Station was completed at St. George's, and served to operate the experimental electric line from Old Market Street to St. George's and Kingswood. This line proved so successful that extensions were laid down the following year and the power station equipment there was increased, and as the result of the working of those sections, the company decided to reconstruct the whole of its lines (till then worked by horse traction) as well as to make large extensions, and to operate the whole system electrically.

The Act authorising this important operation was obtained in July, 1898, and with characteristic energy, the company set itself to carry out the reconstruction. By December 1900 the whole system, covering 28½ route miles, had been brought into electric operation, the completion of this immense undertaking occupying only a little more than two years.

That the system has proved of immense public advantage is shown by the rapid growth of the passenger traffic. In the year 1900, when only parts of the system were as yet electrically worked, 27 millions of passengers were carried, while over the completed system, in 1901, the number reached 37 millions, an increase of 10 millions, being an average of 1⅓ millions per annum per mile of line.

It will perhaps be better in describing the system to give the various sections of the installation separately.

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Power Station Building.

Choice of Site.—From a scientific and practical point of view, the interest of this extensive system of tramways centres in the new Power Station at "Counterslip," St. Philip's Bridge. It occupies a splendid position in relation to the work, being situated as nearly as possible at the centre of the system, the furthest point being distant four miles from the power house. Built alongside the floating harbour, facilities are thus secured for a plentiful supply of water, for the reception of fuel and materials, and for the removal of ashes. The site had but one objection—its want of lateral extension. But it was so satisfactory in every other respect, that it was adopted by the Board without hesitation, and the task of fitting the confined space to the requirements of the system was left to the Engineer. This task has been met in a way that is absolutely unique in tramway engineering equipment—unique alike in design, adaptability and completeness.

Architectural Description.—The leading feature is that the boilers and furnaces and the corresponding parts of that section of the equipment are on the floor above the engine room. The reason for this unusual arrangement is that the most had to be made of a site of very limited extent, while it was of course desirable that the engines and dynamos should be on the ground floor. It was inevitable under these circumstances, that all the other machinery should be taken to the upper story, and that the building should be both lofty and strong enough to provide all the necessary accommodation.

The site had first to be dealt with. It abuts on the river, and as in the case of the Corporation Electrical Station, on the other side of St. Philip's bridge, it had to be closely piled before putting in the foundations. To do this a stout coffer-dam was built around the river front and the water between it and the site pumped out. The ground was then excavated to a considerable depth and about 1200 piles driven in. The concrete foundations have steel girders embedded in them, and upon this solid base is erected the steel framework for the building, which measures 140 feet in length and 52 feet in width outside the walls, the over-all height being 111 feet from the basement to the roof bridge.

The walls are of red brick, closely set with cement, and Bath

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stone dressings have been freely used, so that the outward aspect presents a fine architectural effect, being graceful, dignified and massive, sufficiently ornate to satisfy taste, while at the same time it is solid and businesslike, as the building for such a purpose should be.

The interior of the Power Station is lined throughout with white glazed brick relieved with lines of blue. The basement is 8 feet high, the engine room is 37 feet high, the boiler room is 20 feet 8 inches high, and an additional floor above the boiler room, 15 feet high, contains the tanks, bunkers, economiser, flue, etc.

Chimney-Stack.—The chimney-stack consists of two parts, a brick pedestal below and the steel shell forming the shaft itself, this arrangement being necessitated by the extreme height of the boilers and flue. The pedestal is utilised to contain a spiral stairway giving access to the boiler room floor. The chimney proper is 200 feet high from the base plate on the top of the pedestal, or 265 feet in all above the ground level. The shell is made of steel plates in three thicknesses, being $\frac{3}{8}$-inch at the bottom, $\frac{5}{16}$-inch in the centre portion and $\frac{1}{4}$-inch at the upper end. It is 10 feet 9 inches in diameter at the top, and is there finished off with an ornamental cap. A ladder runs to the top from the base of the shell. The interior of the chimney is lined with firebrick, specially moulded, the thickness of the lining varying from 9 inches at the bottom to $4\frac{1}{2}$ at the top. The shell is riveted to the cast iron base plate, which again is held in position by eight $2\frac{1}{4}$-inch holding-down bolts, built in and running the whole depth of the brick pedestal.

Coal Handling Plant.—Coal is received from barges by a grab bucket, and delivered into a storage tank. About 60 tons per hour are raised and tipped into a hopper, its weight being automatically recorded on its passage to the storage tank, which has a capacity of 486 tons. The fuel is delivered into the bunkers above the boilers by means of a bucket chain conveyor, with a total capacity of 267 tons, and the supply for the boilers is drawn off for the stokers through weighing hoppers. The bucket conveyor, which is 540 feet long, is electrically driven at a speed of 26 feet per minute, and will convey 34 tons per hour.

Boiler Room.—The boiler room contains eight horizontal water-tube boilers arranged in four batteries, each with a capacity of evaporating 8250 lbs. of water per hour, at a steam

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pressure of 160 lbs. and each containing a heating surface of 3140 square feet.

Mechanical Stokers.—Each furnace is fed by an electrically driven mechanical stoker of the "coking" type. The driving shaft runs in a trench in front of the ash-pit, and has at each end a worm gear driven by a motor. Either worm may be thrown out of gear. The ashes are removed by the return line of the conveyor, and are received into a tank outside the building, from which they can be drawn off into barges.

Condensing Plants.—The condensing plant consists of two surface condensers of the "Admiralty" type, each containing 3200 square feet of cooling surface, and each having a motor-driven 8-inch centrifugal circulating pump. The air pumps are of the vertical twin type, one set for each condenser. The exhaust steam passes through an oil separator before entering the condenser.

Hot-well.—The hot-well consists of a cylinder 96 inches long and 48 inches in diameter located in the basement, and the water from this is forced into the water tanks on the economiser floor by two electrically driven three-cylinder pumps, passing through filters for extracting any remaining traces of oil. The make-up valve is situated in the hot-well.

Water Tanks.—The water tanks have a capacity of 12,000 gallons, and from them the feed pumps (which are of the vertical compound duplex type) supply the boilers.

Water Softener.—A "Tyack" water softener, capable of dealing with 3000 gallons per hour, is located in the yard against the chimney base. Experience at the St. George's Power Station had proved this method of treating Bristol water to be satisfactory. The service from the town mains is arranged in duplicate, as a safeguard in the event of water being cut off from either.

Steam Piping.—The steam piping is designed to suit the particular arrangement of the station, there being one 10-inch header in the boiler room and another adjacent to the main engines; and provision is made by the insertion of separators to prevent water passing to the cylinders of the engines. From the lower steam header risers are taken to the stop-valves of the engines, and a ring main is taken around the basement of the station for supplying steam to the auxiliary plant. The steam pipes are lap-welded steel tubes screwed with heavy cast iron flanges, the ends of the tubes being peened over. The exhaust

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from each pipe is carried into a main exhaust pipe 20 inches diameter, in the basement, from which it passes to either condenser or by an automatic valve to the atmosphere by a pipe carried outside the building.

Engine Room.—The engine room on the ground floor is 116 feet long by 48 feet wide and 37 feet high. It contains four 500 k.w. direct-coupled sets, two 50 k.w. direct-coupled lighting sets, the condensers, the air-pumps, five negative boosters, and the switchboard. It also has a 25-ton electrically-driven overhead crane traversing the whole length of the room. The main engines are of the vertical cross-compound Corliss type (built by the E. P. Allis Co., Milwaukee, U.S.A.), with cylinders 22 and 44 inches diameter, and 42 inches stroke, running at 90 revolutions per minute. There are two galleries round each engine, the upper being connected from engine to engine. The fly-wheels, which are 16 feet in diameter and each weigh 40 tons, are built up in 10 semi-steel sections, each section being secured by three bolts between discs pressed on to the shaft. After it is built up in this way the joints in the rim are held together by links on both sides shrunk into recesses. The steam consumption of these engines is guaranteed to be not more than 12·7 lbs. per indicated horse-power, with a mechanical efficiency of not less than 91 per cent.

Generators.—The generators (constructed by the General Electric Co., U.S.A.) are of the 10-pole type, compound wound, and will develop 1250 amperes at 500 to 550 volts as may be required, or 1500 amperes for short intervals. They stand over pits between the H.P. and L.P. engine columns, and the armatures are pressed and keyed on to the main shaft.

Gear.—The gear is of the automatic type with double-ported valves for the steam, and single-ported valves for the exhaust; and there are two eccentrics to the valve gear of each cylinder, one for operating the steam valves and the other for the exhaust valves. Two governors are attached to each engine, one of which operates both the high and low pressure cylinder valve gears, whilst the second or safety governor automatically closes a stop valve placed near the main throttle valve, to act in case the speed should exceed 95 revolutions per minute.

The crank-shaft is provided with journals of 18 inches diameter. Between the cylinders there is a re-heater receiver with coils supplied by steam at boiler pressure.

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Lighting Sets.

The two lighting sets consist of two crank tandem compound high-speed self-lubricating (Bellis) engines, running at 400 revolutions per minute and each having direct-coupled a 50 k.w. 500 volt compound-wound four-pole lighting generator. A centrifugal governor fixed at the end of the crank shaft and acting direct on the throttle valve controls the speed within 3 per cent.

Boosters.

The five negative boosters are placed under the switchboard gallery and draw the return current from the track rails at outlying districts; each consists of two 4-pole continuous-current direct-coupled machines, mounted on a single bed-plate having three bearings. The generator is constructed as a series-wound machine, but its field is connected in circuit with the positive feeders supplying current for the locality so boostered. Separate return cables run from the distant points to be boostered, the extreme ends of which are connected to the track rails by plastic bonds, and the home ends to the negative side of the generator armature, the positive side of which is connected to the negative bus-bar. The generator is thus separately excited, and the current in the armature corresponds with the current in the field, and when 600 amperes (which is the maximum capacity) are passing through both field and armature, the machine gives 50 volts at the terminals of the generator.

The rails are also connected at the Power Station by bare cables, equivalent in section to 4 square inches, to the negative bus-bar.

Switchboard.

The main switchboard consists of white marble panels 8 feet in height, and 2 inches thick, bolted to angle iron frames on a raised gallery. It consists of four generator panels; twenty-one feeder panels, some of which are on the auxiliary board, as described later; two lighting generator panels; one panel containing the main station voltmeters and the Board of Trade test instruments; and one lighting and power circuit for the Power Station circuits, also five booster panels, all being furnished with connections and switches of the most approved type and design.

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The arrangements are such that the lighting and power panel may be supplied either from the lighting sets or from the tramway generators.

Auxiliary Switchboard.

There is also an auxiliary switchboard on a gallery above the main switchboard, containing the feeder panels supplying the parts of the system originally driven from the St. George's Power Station, and also panels controlling the feeders to the various depôts and car-sheds throughout the city, for both lighting and power.

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SOME NOTES IN CONNECTION WITH ELECTRICAL WORKS IN BRISTOL.

By H. FARADAY PROCTOR, Assoc. M. Inst. C.E., M.I.E.E., City Electrical Engineer of Bristol.

Although Bristol was far from being amongst the first of English towns to obtain the benefits derivable from the commercial use of electrical energy, it to-day stands in the foremost ranks in this respect.

The Municipality owns and operates the electrical undertaking for the distribution of energy for public and private lighting, and the application of power on consumers' premises; whilst a very excellently managed tramway undertaking is in the hands of a company whose power station is in close proximity to the older of the generating stations belonging to the Corporation.

Without entering into a minute description of the Municipal Electrical Department, it may be of interest to indicate the outline of the system, as it is hoped that some of the Members and visitors may find both time and inclination to visit the works.

Parliamentary Powers.—Parliamentary powers to work an Electricity Department were obtained in 1883, but it was not until 1892 that a scheme was adopted and put in hand.

System of Supply.—Having regard to the large area to be supplied—an area measuring roughly 6 miles by 4 miles—the system of distribution to be adopted was naturally a high-tension alternating-current system, the current being sent out from the works on feeder cables, and being then reduced to a suitable pressure for distribution at transforming sub-stations. The periodicity is unfortunately high, being 93 alternations per second. Present experience shows that a much lower periodicity, whilst it would still have been equally suitable for

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lighting purposes, would have greatly facilitated the extended use of alternating-current motors. To meet the difficulty experienced under some conditions of driving certain classes of plant with alternating-current motors, a system for the distribution of continuous current was recently inaugurated. The pressure chosen was such as to enable the common use of the generating plant for either the public lighting or power supply, or indeed to enable the interchange of current between this section of the system and that of the tramway undertaking in the event of that undertaking becoming the property of the Corporation.

Temple Back Generating Station.

Locality.—There are now two generating stations, the older being situate at Temple Back, well in the centre of the area supplied. It is bordered on one side by the floating harbour, which provides means for the cheap delivery of coal from South Wales, and at the same time an ample supply of water for condensing purposes.

Water.—This water, after treatment by caustic soda in softeners, is also used for the boiler feed; its hardness varies from 18 to 23 degrees, sometimes in so short a space of time as six hours.

Boilers.—There are at these works twelve Lancashire boilers and two Babcock water-tube boilers, fitted with Vicars and Meldrum's mechanical stokers, one boiler only being temporarily hand-fired.

Coaling.—The coaling arrangements possess no special feature worthy of mention. Bucket elevators and worm conveyors are used, and driven mainly by electric motors. An Avery automatic coal-weighing machine is in use, and operates in a very satisfactory manner so long as the size of the pieces of coal that pass through it is fairly regular.

Green's Economisers.—Green's economisers are used so far as the dimensions of the site allow.

Feed Service.—The feed service is at present under revision, being completely brought up to date; tenders for the new plant not having as yet been accepted, description of it cannot be given here.

Engine Room Plant.—The engine room is also at the present

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time in a transition stage. The whole of the engines, comprising an aggregate of about 5500 indicated horse-power, are of the Willans central-valve type. They are all single-acting, tandem-compound and mostly three-line engines, coupled direct to alternators or dynamos, the largest engines in the station indicating 750 horse-power each.

Four of the smaller alternators are now being displaced; a continuous-current multipolar dynamo and a Parsons-Siemens steam turbo-dynamo taking their place. These are required to meet the rapidly increasing demand for continuous current for power purposes, it being the intention to gradually convert the Temple Back Works into a continuous-current station, as the demand for such current increases. It will be understood that it is more advantageous to have this plant, from which the comparatively low pressure current (500 volts) is distributed, in a central position than that from which the 2000 volt alternating current is sent out.

It is interesting to note that in displacing three of the small steam alternators, having an aggregate capacity of 386 kilowatts, space is provided sufficient to enable the placing of 1000 kilowatts of steam turbo-dynamo sets (two sets of 500 kilowatts each), and also the necessary condensing plant for the same.

Steam Turbines.—Before adopting this new type of plant, careful inquiries were made and sundry works, where steam turbines are used, were visited. The information gained was highly satisfactory, and the following points were especially noticed in favour of its adoption:

The ground space required is comparatively small.

The vibration, if the plant is properly constructed and maintained in balance, is negligible.

The steam consumption, where the initial steam pressure is not very high (at the Temple Back Works it is only 125 lbs.) and the vacuum is good, compares favourably with any other type of plant.

The maintenance, unless trouble is experienced at the commutators due to sparking, is small.

The exhaust steam is absolutely free from oil, due to the fact that no cylinder lubrication is used.

The purity of the water and absence of all greasy matter is a subject which largely affects the smooth and economical working of electricity works. It is one which has received

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a considerable amount of time and attention in this Electricity Department.

Cream Separator.—Some years ago a cream separator was tried as a means of extracting, or separating, the oil from the feed water which was returned from the condensers. The separation was found to be very satisfactory, but the appliances were not then made for the somewhat hard usage and continuous working to which they must be subjected in a boiler-house. The method of extracting the oil now adopted at these, as well as the new works, is that of separating the oil from the exhaust steam before it passes to the condensers. There being more difference between the specific gravity of steam and oil than between oil and water, it is reasonable to suppose that separation on the principle of gravitation will be more easily and perfectly accomplished on the principle of working now adopted. This supposition has been borne out by the results, the employment of several series of baffle plates inserted in the path of the exhaust steam on its way to the condensers having resulted in the diminution of the oil present to about three grains per gallon of water.

Switchboards.—The switchboards are also in a transition state; practically the whole of the boards will very shortly be of the well-known Ferranti cellular type, built solid into the walls of the building; no material whatever of an inflammable character being used in their construction.

Avonbank Electricity Works.

Site.—As the site at Temple Back became fully occupied and an exorbitant charge was required for the acquisition of land adjoining, a site for the new works was procured in a neighbourhood which, although still fairly central, is 1½ miles distant from the Temple Back Generating Station.

The Avonbank site is 10 acres in extent, and adjoins the feeder canal, the Great Western Railway, and a colliery which is at present disused.

It is a matter of regret that although these works were formally opened on February 19th of this year, they have not as yet been taken into regular use, owing to the usual falling off in the demand for electricity consequent upon the approach of the summer season. The official trials of the plant have not

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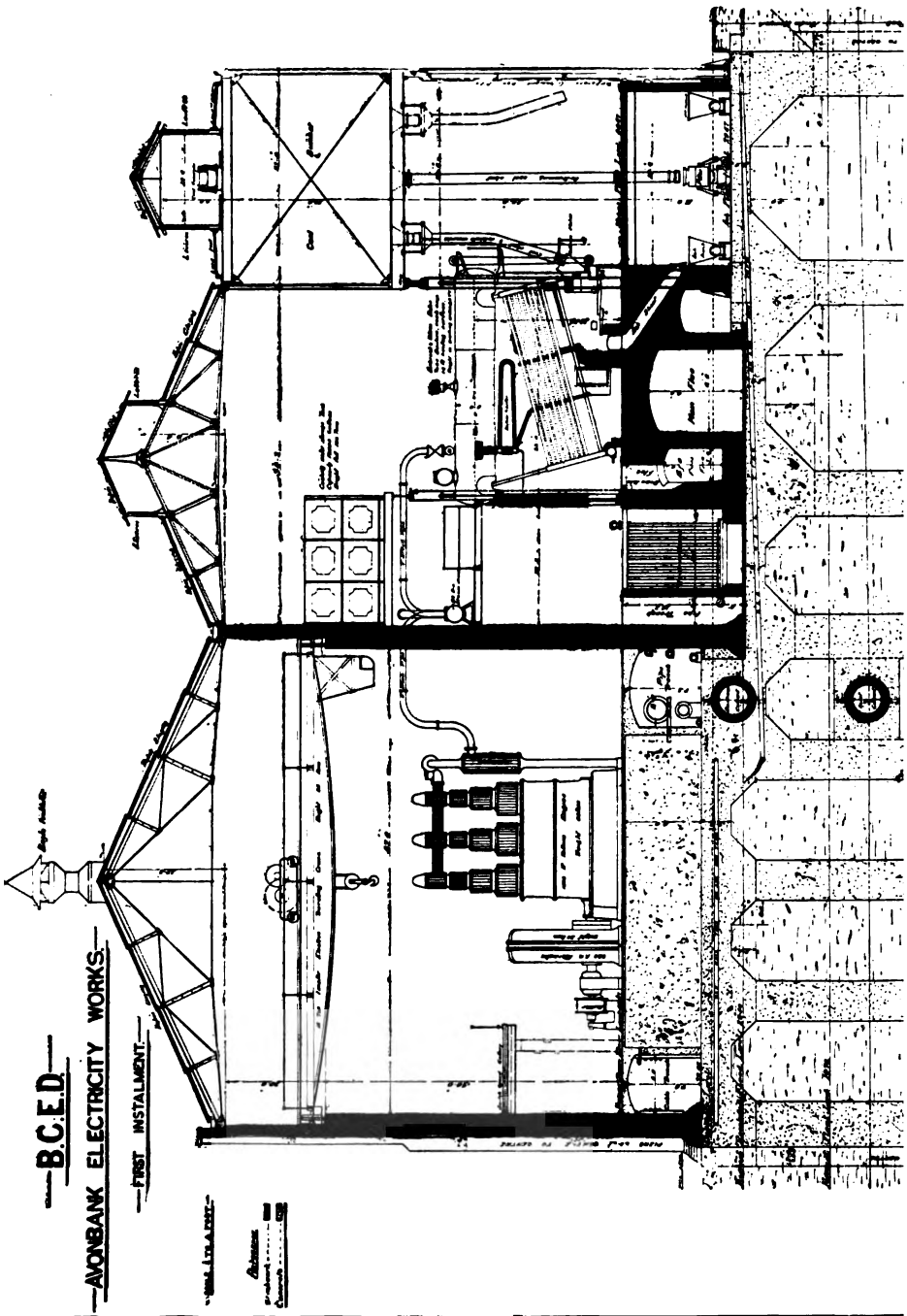

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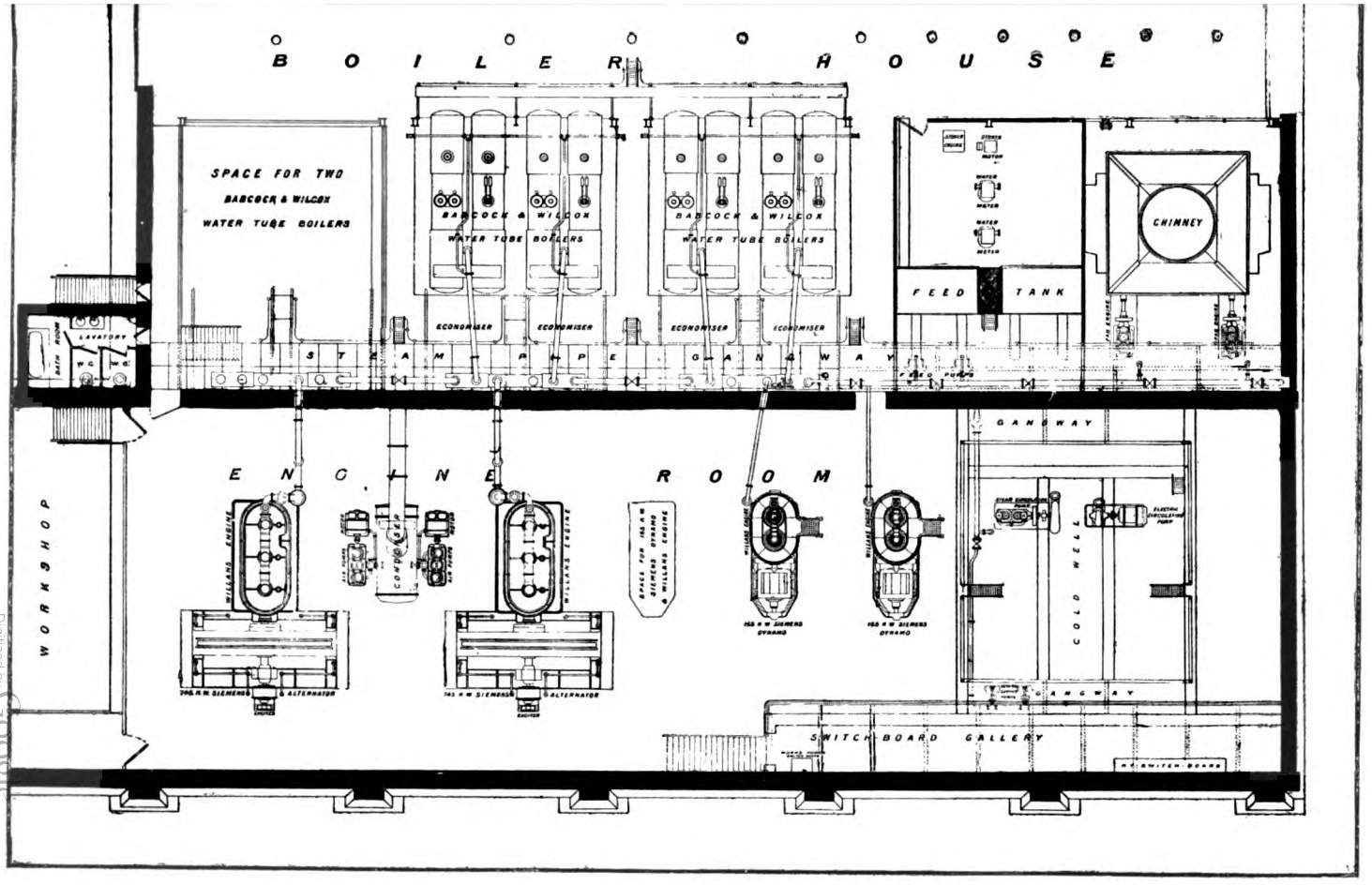

PLATE II.

GENERAL PLAN. 1ST INSTALMENT AVONBANK ELECTRICITY WORKS.

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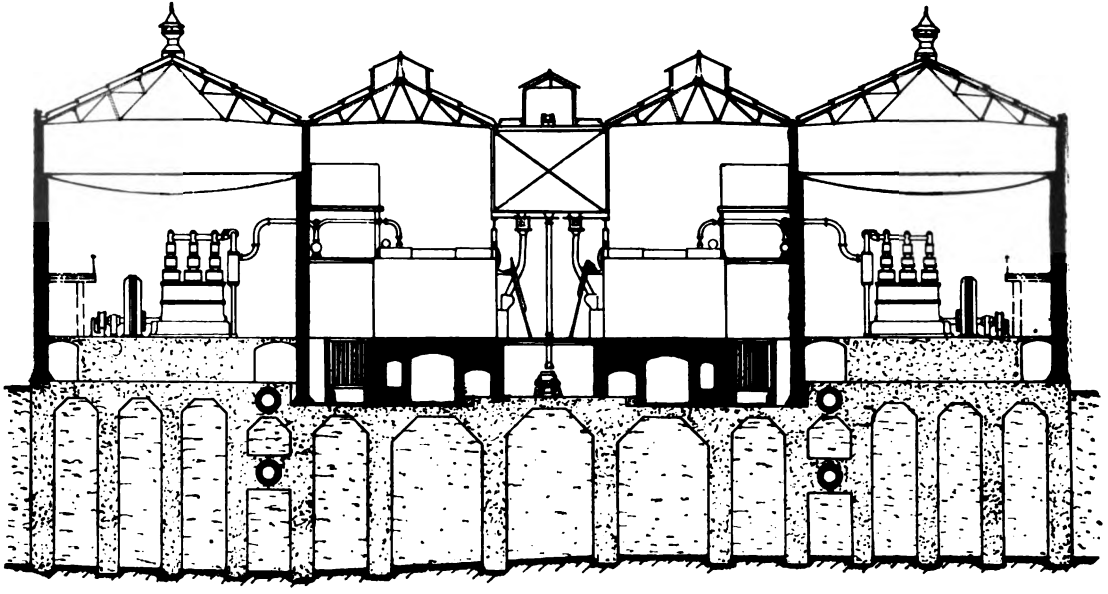
B. C. E. D.

AVONBANK ELECTRICITY WORKS.

PROPOSED ARRANGEMENT OF COMPLETED WORKS.



CROSS SECTION

PLATE III.

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yet been taken, and some statistics as to the results of working the more modern plant, which might have proved of some interest, are thus not forthcoming.

One of the chief items of interest in connection with the two Generating Stations has been the formation of the foundations. At the Temple Back Works a bottom was found at an average depth of 33 feet below normal water level. Larch piles were driven all over the whole area at about 4 feet centres, and upon these, after they had been tied by timber capping pieces, the concrete foundations were placed; the latter being of lime concrete 4 feet thick, and in addition to this an engine bed of cement concrete 7 feet thick under the whole engine room. The two brick chimneys, each 180 feet high, 9 feet internal diameter at the base, are built upon a granite base placed upon a bed of cement concrete, the timber piles under this being spaced 3 feet apart.

Avonbank Foundations.—Although timber foundations suffice for the Temple Back Works, where the timber is always under water, such a construction was deemed unsuitable at the Avonbank site, water not being present throughout the land at all times. The foundations have been constructed of cement concrete (seven parts of ballast, two of sand, and one of cement) in the form of walls resting upon the hard red marl at an average depth of 34 feet below the ground level. The ballast used was of such size that about one-half of it would pass through a 1-inch ring, and the remainder through a 2-inch ring. Bideford sand was used throughout, and the cement was so finely ground as not to leave a residue exceeding 10 per cent. on a mesh of 6400 divisions to the square inch. The usual tests for tensile strain were specified. The concrete used for the floors and arches over the walls was of a richer composition, being mixed in the proportion of five parts ballast, two of sand, and one of cement.

The foundation walls run longitudinally with the buildings, and are situated directly under the lines of weight arising from the superstructure and machinery. The maximum weight upon the concrete foundation walls is 12 tons per foot run, and that upon the red marl, upon which the foundations rest, is 4 tons per square foot. The walls are eight in number; those under the two superstructure walls of the engine room, the backs and fronts of the boilers, and also the fronts of future boilers, are

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each 4 feet 6 inches in width; the two last mentioned having to carry the weight of the coal bunkers in addition to the weight of the boiler fronts. The remaining three walls, placed under the engine room, are 4 feet in thickness, the weight on these being distributed by the block of concrete 11 feet thick forming the engine bed.

Preliminary to the formation of the trenches for the foundation walls, a sump 10 feet square was sunk to a level 5 feet lower than any of the works to be executed. Two centrifugal pumps, 5 inches in diameter and 3 inches in diameter respectively, were connected; the latter, however, usually sufficed to keep the water under. The timbering of the trenches formed an interesting feature of the work; boarding from 2 to 3 inches thick, 12-inch by 6-inch poling pieces, and 12-inch by 12-inch struts, were used. The only fault which occurred during the construction was that of a sinkage, to the extent of about one foot, of the dumpling between Nos. 1 and 2 trench owing to the operation of one of the 5-ton locomotive cranes on the track laid upon it; this ground between the trenches being only 8 feet in width.

Superstructure.—The first instalment of the works forms in section only about one-half of the width of the ultimate scheme, when there will be two boiler-houses parallel to one another, the boiler fronts all facing one common stoking space, and on each side of the same. By this arrangement one common coal storage has been secured available for use with any of the boilers, and the provision of duplicate coal-conveying plant has been avoided. The boiler-houses may each be extended to a length of 1000 feet, when the capacity of the engines would amount to 75,000 horse-power, even though the size of unit now in use were not increased.

The superstructure forming the engine-room is built of Cattybrook bricks (a local brick which has been tested to 543 tons per square foot). The roof is entirely of Hope's glazing. The remainder of the superstructure forming the boiler-house, stoking space, and coal bunkers, is entirely of steelwork, pneumatic riveting having been employed in the completion of the work on the site.

Coal-handling Plant.—The coal-handling plant includes one of the novel features of the equipment, consisting of a gravity return railway.

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An embayment, to allow coal vessels lying alongside without interfering with the free way of other vessels desiring to pass, has been formed at the Feeder canal immediately opposite to the works. Upon a wall of this embayment is erected the coal discharging plant. This consists of electrically driven winding gear working a Hone's grab.

The Hone's grab of 15 cwt. capacity, has a vertical lift of 55 feet. The lifting motor absorbs 25 electrical horse-power, and the racking motor $3\frac{3}{4}$ horse-power. The plant is required to discharge 40 tons of coal per hour, but has so far not exceeded 35 tons owing to a difficulty experienced in lowering empty. The speed reduction from the motor drive is effected by means of a double thread-worm, $3\frac{1}{2}$-inches pitch, $5\frac{1}{2}$ inches diameter, running on ball-bearings and with a ball thrust. The intention was to lower out by reversing the motor, but it has been found that the thrust is sufficient to drive the worm and motor backwards, and the temporary use of brakes, for lowering, limits the capacity of the plant.

The Hone's Grab discharges into an automatic coal-weighing machine on a beam and spring balance principle, electrically controlled. This machine appears to work most satisfactorily.

After passing the weighing machine the coal falls into a truck running upon a gravity-return railway. The working of this railway is perhaps the most novel and fascinating operation to be seen in the works. The railway is supplied by Messrs. Babcock and Wilcox, and the idea of its working comes from America. The full truck of coal is shoved off from the level platform under the weighing-machine on to the railway, which has a downward inclination of 1 in 33, to the nearest end of the generating station buildings, where a shute into the boot of the coal conveyor is situated. The loaded truck runs by gravity down the incline, and at a certain stage in its journey picks up a block attached to the end of a wire rope, which it carries with it, and this raises, through an elevation of a few feet, a heavy counter-weight attached to its other end. The sides of the coal truck automatically open when it reaches the end of its journey and the bottom is so constructed that the coal is completely discharged immediately. The counter-weight has then sufficient energy stored to return the now lightened truck to the level platform ready for another charge of coal.

The truck has a capacity of 15 cwt. and will work at the

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rate of 100 journeys per hour, giving a discharge rate of 75 tons of coal per hour. The length of the railway is about 200 feet: the average speed is therefore about 7½ miles per hour, including stoppages.

The coal discharged from the truck passes through a shute into the automatic filler of a Hunt bucket conveyor. The filler consists of a hollow drum of large diameter revolving on a horizontal axis; the buckets forming the complete round of the conveyor, travel immediately under the drum; the chain of buckets causes the drum to rotate, its peripheral rate of movement corresponding with that of the buckets. In the drum, holes are arranged so that one of these comes directly over each bucket as they together move under the axis of the drum. The coal delivered into the drum is thus discharged into the buckets, each of which is filled without the spilling of any coal. The buckets are so supported that they hang vertically no matter what the inclination of their line of movement; they can, however, only move in one vertical plane; they are free to rock when the movement of their lower extremity is interrupted. The continuous chain of buckets passes up within the building, at one end, and traverses its entire length in the coal discharging gangway formed in the lantern roof immediately over the coal-bunkers. It then passes down the building at its other end, and returns underneath the level of the stoking floor, a few feet in front of the boilers.

Interrupters are placed at intervals along the coal discharging gangway; any one of these being "set" causes all the buckets to rock and discharge their coal at this particular place. Long shutes, arranged at intervals, extend from the coal bunkers through the stoking space to the low level on which the buckets return, and these may be caused to discharge their coal from any portion of the bunkers through a *filler*, similar in its operation to that already described, into the buckets by which it may be carried round again to any desired position in the bunkers. The risk of allowing coal to fire or deteriorate through remaining for any long time in one position, from which it is not convenient to use it, is thus avoided. The conveyors are driven by an electric motor, which at the present time absorbs 7 horse-power when discharging coal at the rate of 40 tons per hour. This includes a lift of about 55 feet, and the movement of a length of 450 feet of buckets; the whole of this apparatus being new, and

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there being a very great number of working parts, it is most probable that the horse-power absorbed will be reduced to the figure given by the contractors, namely, 5 horse-power.

The coal storage capacity arranged for is sufficient to maintain the full load on all the boilers for 80 hours when the ultimate scheme, including the doubling in width of the works, is completed. Since the output of the lighting station in Bristol does not, even in the depths of winter, exceed the full load of the plant for twenty-one hours per week, the bunkers may be considered to have a minimum of four weeks' supply.

The boiler-house contains 4 Babcock-Wilcox boilers, each of 4020 square feet heating surface, and having an evaporative capacity of 14,000 lbs. of water per hour. These are fitted with Meldrum stokers worked in conjunction with mechanically-induced draught.

The chimney stack, 70 feet high and 9 feet internal diameter, is formed of mild steel plates; two fans, each 7 feet 6 inches diameter and 25 inches in width, driven by Bumstead and Chandler single-acting compound engines of 75 brake horse-power, provide the draught; each of these fans at 255 revolutions per minute will deliver 97,000 cubic feet of cold air (60° F.) at a water gauge pressure of 2½ inches: they are, however, designed to run at a much higher speed when necessary. The draught is automatically controlled, so that any fall in the pressure of the steam system opens wider a valve admitting steam to the induced draught engines, thereby increasing the intensity of the draught and resulting in a correction of the steam pressure at the boilers. The reverse action takes place should the steam pressure rise too high; the mechanism operating the valve is constructed upon the principle of the Bourdon pressure gauge.

In the engine room the arrangements are simple in the extreme: there are at present only two main generating sets; these are of double the size of the largest sets of plant at Temple Back; each machine being capable of an emergency load of 920 kilowatts: in other words, each machine can supply energy to keep alight at one time the equivalent of 30,666 lamps of 8 candle-power. These two sets, together with some smaller sets for the generation of energy to drive the numerous motors, switchboards for the control and distribution of current, surface condensing plant and sundry pumps, together with a 15-ton electric travelling crane, form the equipment of the engine room.

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Pipe-Work.—The whole of the steam pipe-work, of which there is perhaps an exceptionally small amount, is of mild steel. Those pipes which are of 5 inches diameter or less are welded and have welded flanges; those larger than 5 inches have riveted flanges. All brass and copper work has of necessity been avoided, owing to the use of steam at 200 lbs. pressure together with an additional super-heat of 150° F.

Cables.—The sundry cables used in the transmission of energy, of which there are about 160 miles laid, are all jute or paper insulated, lead sheathed and steel armoured, the steel armouring being served with yarn or jute impregnated with a composition of a bituminous character. These cables are laid direct in the ground, common bricks being laid loosely over them, before the trench is filled in, merely as a warning in the event of any subsequent opening of the ground. The cables, even those which have been underground for nine years or more, do not show the slightest signs of ageing, the outer covering of jute, with the exception of two special lengths, being in sound and perfect condition.

The sub-stations, which are 57 in number, are mostly built of Cattybrook brick in cement mortar, the walls being usually 2 feet in thickness. The last two sub-stations constructed, however, have been formed of 3 to 1 concrete. The latter have been found somewhat cheaper, and the nature of concrete facilitates the formation of ducts or trenches for the running of cables. The spaces round the cables, where they enter the sub-station, are all carefully sealed to prevent the entrance of either water or gas. Little trouble has been experienced from water percolating through the walls, although many of the sub-stations are placed at low levels, it being the general practice for them to be situated whenever possible under the footways. In only one instance has there been any explosion of gas; and although this is now perhaps six months ago, no cause for the occurrence has become apparent. The chambers are all provided with a large manhole to allow of the removal of apparatus, and a small manhole, placed within the cover of the latter, serves for inspectional purposes. The joint of the large cover is stemmed; the small manhole is provided with an inner cover with a rubber joint and an outer or surface cover merely resting in a lip without any attempts being made to exclude surface water. Each sub-station is provided with 6-inch up-cast and down-take pipes for

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ventilation purposes, the heat generated by the transformers providing ample circulation, except in the case of very large sub-stations.

Charges.—As regards the rates charged for current sold to consumers, where current is used for power purposes, a flat rate of 1½*d.* per unit, subject to a discount according to the quantity consumed, is adopted. For current used for lighting purposes, the simple plan of charging 5*d.* per unit subject to discount is complicated by allowing consumers to use current in the daytime at two-thirds of the rate charged at other times. This has been done to encourage the use of current at times other than the hours of darkness. The importance of increasing the earning hours of the plant may be briefly set forth in the statement, that although the capital charges alone (interest and redemption) amount to over 1½*d.* per unit sold, current for either public lighting or power supply can be sold at a profit at considerably less than this figure.

In such a paper as this, no boundary having been defined, the matter if perused or recited "in extenso" would become tedious; leadings have therefore been inserted to enable, in lieu thereof, a reference to any particular section.

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SEA MILLS SEWAGE DISPOSAL WORKS, NEAR BRISTOL.

By A. P. I. COTTERELL.

The Sea Mills sewage disposal works were designed to replace a sewage farm in another part of the district that had become insufficient, and was badly situated for the accommodation of recent building extensions. They were also constructed to treat the sewage from Stoke Bishop that formerly ran direct into the river Avon.

The works are placed about ¼ mile from the river Avon, in a narrow valley cut through the Dolomitic Conglomerate, portions of the tanks being founded upon the solid rock and portions upon the alluvial soil with which the bottom of the valley is filled. They are designed to accommodate a population of 10,000, the present population being nearly 7000, and are so arranged that extensions upon the same lines may be made up to a population of 30,000.

The effluent discharges by a brick culvert 3 feet 6 inches by 2 feet 4 inches internal dimensions into the tidal portion of the river Avon at a point below low water, but the Local Government Board, in giving their sanction, required the Barton Regis Rural District Council to discharge only at certain states of the tide, viz. between high water and an hour and a half before low water. They stipulated that the sewage should be capable of being treated with chemicals, and, after such treatment, together with subsidence in tanks, should be stored, except during the hours above stated.

The works were therefore designed on the following lines, viz.:—The 24-inch sewer from Westbury, and the 18-inch sewer from Stoke Bishop, which is carried across the valley on an aqueduct (constructed also to form the northern boundary fence of the land), join at a gauging chamber, where brass plates indicate at any moment the rate of flow through either sewer in gallons per minute and gallons per hour.

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Immediately after junction the sewage flows through a revolving screen of large mesh automatically driven by a water-wheel, the sewage itself being used as a motive power.

Provision is made for the addition of a precipitant to the sewage before passing over the water-wheel, so that thorough mixing may take place. The liquid thence flows into two grit chambers placed underneath the engine-house floor. The grit chambers are formed with tapered sides and a discharging valve at the bottom, so that all sludge or grit can be forced into a sludge tank placed underneath the press-house without emptying the chamber. To assist in the deposition of the sludge, and to keep the sides of the grit chambers clean, a large number of nozzles are arranged in rings, through which air or water can be discharged under pressure and thus sweep the whole of the chamber clear of all deposit.

From the grit chambers the sewage passes through a distributing channel, and thence into three covered tanks, each 171 feet in length and 12 feet in width, capable of being used for subsidence or for anaërobic action. Only two tanks are in use at present. When all are in use they are capable of taking one day's dry-weather flow from the maximum population.

The clarified effluent from the septic tanks passes off in the usual way through a slotted pipe, and thence down a slide into the large covered storage-tank, which is capable of holding 600,000 gallons. The discharge from this tank goes direct into the brick culvert above mentioned, but is controlled by a hydraulic penstock 36 inches in diameter worked automatically by a tidal clock, and so arranged that the final effluent is discharged into the Avon during the hours when such may be allowed.

In the septic tanks are large V-shaped scrapers which can be made to work slowly on an endless rope throughout the tank and draw off any sludge or debris into a V-shaped discharge notch at one end, whence it passes into a sludge chamber without emptying the tanks.

Both sludge chambers are provided with floating arms for drawing off supernatant water (such water being returned to the sewer by a centrifugal pump) and also with suction pipes connected with the sludge ram from which the sludge is forced into a 27-inch square Johnson's sludge press containing twenty-four chambers in the usual manner. Ample arrangements are also

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made for liming the sludge on a liberal scale in view of the stale character of much that is drawn off.

The works, as will be seen, partake in many particulars of the usual features common to such installations, but there are two points of interest to which attention may be drawn. The first is the automatic discharge controlled by a clock. This clock is the joint invention of Mr. A. M. Hunt and Messrs. Kemp Brothers, on suggestions made by the Author. It is designed upon the alarum principle with five faces, and is so arranged that it actuates the penstock both for opening and closing twice in every day. The hydraulic accumulator contains sufficient water for four actions of the penstock. It is charged each day by the attendant, who at the same time sets the clock for the two tide discharges of the day, and needs not to trouble any more about this part of the works. The periods of discharge are adjusted to correspond as closely as possible with the periods on the tide table.

The obvious advantage of a penstock controlled in this manner will be seen by all who have occasion to discharge at specified times. Were it not for the clock it would be necessary to employ a night and day staff; but by means of the clock (which cost less than 150*l.*) there is no need of a night staff, the discharge taking place with even greater regularity than the most efficient manual labour would probably afford.

The other point of interest is the scraper placed in each septic tank. It runs upon iron guides and is drawn to and fro by a wire rope passing by means of sheaves at the ends and top of the tank round a drum driven by belting from the gas engine.

The speed of the scraper is a little under 2 feet per minute, and the gearing of the drum is so arranged that the scraper cannot overwind, but immediately it reaches the end of the tank a weight working on a horizontal screw throws the gearing out, and the scraper remains stationary until the attendant reverses the apparatus.

The only attention found necessary for the works is one qualified man, and a boy to keep him company. The man has a printed list of instructions as to his duties, which he can get through readily in far less than a day's working time.

The cost of the works has been 10,800*l.* exclusive of land and superintendence.

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DESCRIPTION OF THE YEO RESERVOIR AND PUMPING STATION AT BLAGDON, SOMERSET, OF THE BRISTOL WATER-WORKS COMPANY.

By H. W. PEARSON, M. Inst. C.E.

The Yeo reservoir being at too low a level to admit of the water gravitating to Bristol, the water has to be raised by pumping into the North Hill tunnel, whence it gravitates to the reservoirs at Barrow, where it is filtered, and thence gravitates to the lower parts of Bristol, some portion of the water being again pumped to a greater elevation for the service of the upper parts of the city. The original works of the Company, including the North Hill tunnel and two of the reservoirs at Barrow, were designed by the late Mr. James Simpson, Past President of the Institution of Civil Engineers; another reservoir and filter beds at Barrow, the pumping station at Chelvey, and the gravitation works from the Sherborne spring, together with other works of the Company, have been added from the designs of Messrs. Taylor, Sons and Santo Crimp, Members of the Institution of Civil Engineers.

Particulars of the Yeo Reservoir Pumping Station and other Works Designed by T. and C. Hawksley.

Yeo Reservoir.

Construction authorised by Acts of Parliament in 1888 and 1889.

Area of watershed draining to reservoir, 5300 acres.

Area of surface of water when reservoir is full, 450 acres.

Capacity of reservoir, 1,700,000,000 gallons.

Maximum depth of water, 37 feet.

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Compensation water delivered daily to river below embankment, 1,900,000 gallons.

Estimated quantity of water available from these works for distributing during a period of three dryest consecutive years, including supplies brought to reservoir and pumping station by lines of pipes from Rickford and Langford springs, 6,000,000 gallons per diem. This is in addition to the existing supply from the other works of the company.

Length of embankment, 530 yards.

Maximum height of embankment, 43 feet.

Puddle trench sunk through the red and variegated marls and a layer of grey dolomitic conglomerate, all of the Keuper series, on to a bed of watertight red marl. Maximum depth of puddle trench below natural surface of ground, 175 feet.

Diameter of tunnel for passage of floods during construction of embankment, 10 feet.

Main valves in tunnel—two sets in tandem, each 4 feet 6 inches by 1 foot 9 inches.

Length of weir at head of by-wash for passage of floods, 180 feet.

YEO PUMPING STATION.

Two receiving tanks, supplied with water from the Yeo reservoir, and by the lines of pipes from the Rickford and Langford springs. Capacity of each tank, 567,000 gallons. The water gravitates from the tanks to the pumps in the engine houses.

Engines and boiler houses, etc.:—

The two coal stores:

Coal delivered by railway wagons on to gantries.

Capacity of each coal store up to level of gantry, 365 tons.

Elevator in each coal store for supply of coal to mechanical stokers of boilers.

The boiler house contains:

Six Lancashire boilers, 7 feet 6 inches diameter by 30 feet long.

Mechanical stokers for boilers by Vicars and Co.

Two sets of Green's fuel economisers for heating feed-water.

Feed pumps in duplicate.

Steam pressure in boilers, 100 lbs. per square inch.

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Two engine houses, each of which contains:

Two compound rotative beam engines.

Estimated maximum indicated horse-power, 170.

Speed, 16 revolutions per minute.

Cast-iron beams, length 28 feet 5½ inches, centre to centre of end gudgeons.

High pressure cylinders, 21 inches diameter by 5 feet 3 inches stroke.

Low pressure cylinders, 34 inches diameter by 7 feet stroke.

Surface condensers furnished with gun-metal tubes.

Main pumps, bucket and ram type, one to each engine, 30 inches diameter by 3 feet 6 inches stroke.

Delivery, each pump per revolution, 106 gallons; per minute, 1696 gallons; per twenty-four hours, 2,442,000 gallons; after allowing for slip and for running during twenty-two hours per diem, 2,000,000 gallons.

Three engines working together during twenty-two hours will therefore pump 6,000,000 gallons.

Maximum head against pumps, including friction of water in pipes, about 250 feet.

Pipe Lines.

All laid with cast-iron socket and spigot pipes jointed with lead.

From Rickford springs to Yeo reservoir, 27 inches diameter, 1¾ miles in length.

From Langford springs to Yeo pumping station, 21 inches diameter, 3½ miles in length.

From Yeo pumping station to North Hill tunnel, 30 inches diameter, 5 miles in length.

Contractors for the Yeo reservoir, Pethick Brothers; for the buildings of the pumping station, Hodson and Son; for the engines and other machinery, Glenfield and Kennedy, Limited; for the pipes, Cochrane and Co.; for the pipe laying, Pethick Brothers, and Lloyd and Son.

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Interception and Purification of Drainage from Villages, Farmsteads, etc., within the Watershed of the Yeo Reservoir.

The villages of Butcombe, Compton Martin and Ubley, and part of Blagdon, are situate within the watershed of the Yeo reservoir. There are three separate treatment works for drainage from the villages, from each of which the purified effluent is discharged on to land adjoining the river Yeo below the embankment of the Yeo reservoir. The treatment works are all of similar character, the drainage in each case being treated on the Exeter septic tank system. The Blagdon treatment works to be visited are described below.

Blagdon Drainage Treatment Works.

Grit Chamber.—Road detritus and other heavier materials are deposited in this chamber before drainage flows into septic tanks.

Septic Tanks.—Two, each 40 feet by 10 feet, by 9 feet 6 inches deep. Capacity of each tank, 23,750 gallons. Organic matter acted on in these tanks by anaërobic microbes.

Aërator.—Drainage, partially decomposed, flows from septic tanks over an aërator, and becomes mixed with air.

Filter Beds.—Six, each 20 feet long by 16 feet wide and 4 feet deep. Filtering medium, crushed clinkers; capacity of each bed, including clinkers, 8000 gallons. In filter beds, aërobic microbes are cultivated, which complete the purification of the drainage.

Land.—The effluent from the filter beds passes on to land on which osiers are being grown before entering the river Yeo below the reservoir. The effluent from the other two treatment works is discharged on to adjacent land below the Yeo reservoir.

Moderating Tank.—100 feet long, 33 feet 6 inches wide and 3 feet deep. This tank is introduced to take excess quantities of drainage during moderate storms, the excess drainage afterwards flowing into the septic tanks and filter beds.

Contractors for the drainage works, J. and T. Binns, J. and S. Roberts, Limited, and The Septic Tank Syndicate, Limited.

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In the afternoon of Friday, July 11, *the Members formed two parties. The first party made visits of inspection to the new power station of the Electric Tramways, Tucker Street, where they were received and shown over the works by the managing director; and the Corporation electric station at St. Philip's, where the Members were received and entertained to tea by Alderman Pearson.*

The second party visited the Corporation depôt at St. Philip's, including refuse destructor, stabling for 150 *horses, workshops, artificial stone-making plant, etc. The Members were received at the depôt by Alderman Cope Proctor, J.P., Chairman of the Sanitary and Improvement Committee. The Members afterwards proceeded to the works of the Bristol Wagon and Carriage Company, Lawrence Hill, where they were received and shown over the works by the managing director, who entertained the Members to tea.*

On Saturday, July 12, *the Members were again divided into two parties for the inspection of works. Party A proceeded by train to the new reservoir, at Blagdon, of the Bristol Waterworks Company, a visit made by the kind consent of the directors. Party B proceeded by steamer, kindly provided by the Docks Committee, down the gorge of the river Avon to Avonmouth, where the Members landed and inspected the dock extension works in operation.*

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APPENDIX.

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STATISTICAL RETURNS

On the following subjects lie at the Offices of the Association, 11 Victoria Street, Westminster, S.W. Those marked thus * are in duplicate, and can be borrowed for perusal by Members on application to the Secretary. Those *not* marked * can only be inspected at the Offices.

N.B.—Please Quote Reference Number.

(Members are requested, when sending statistics, to kindly send them in duplicate if possible.)

Ref. No.

Drainage Connections (Private).

11. *Information from various towns. Compiled by H. Richardson, A.M. Inst. C.E. 1902.

Drainage (House).

1. Information from 31 towns. Compiled by J. Atkinson, A.M. Inst. C.E., Stockport. 1894.

Drainage (New Buildings).

49. *Information from various towns. Compiled by E. J. Lovegrove, M. Inst. C.E., Hornsey. 1896.

Fire Brigades.

36. *Information from various towns. Compiled by G. T. Lynam, A.M. Inst. C.E., Burton-on-Trent. 1899.

Horses (Cost of Keeping).

2. Information from 29 towns. Compiled by M. Petree, A.M. Inst. C.E., Grimsby. 1896.

Lighting (Electric).

3. Information from 38 towns. Compiled by J. W. Brown, A.M. Inst. C.E., West Hartlepool. 1894.

4. Information from 88 towns and 10 London vestries. Compiled by J. W. Cockrill, A.M. Inst. C.E., Great Yarmouth. 1891.

5. Information from 58 towns. Compiled by W. A. Davies, A.M. Inst. C.E., Aston Manor. 1893.

40. Information from 36 towns. Compiled by E. J. Silcock, A.M. Inst. C.E., King's Lynn. 1896.

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Ref. No.

LIGHTING (GAS).

6. Information from various boroughs. Compiled by J. W. Bradley, A.M. Inst. C.E., Nelson. 1895.

7. Information from 38 districts as to undertakings in the hands of Local Authorities. Compiled by P. Ross, A.M. Inst. C.E., North Bierley. 1896.

LIGHTING (PUBLIC STREET).

8. Information from 21 towns. Compiled by A. H. Campbell, A.M. Inst. C.E., Canterbury. 1895.

9. Information from 54 towns. Compiled by C. C. Smith, Dalton-in-Furness. 1892.

48. *Information from various authorities. Compiled by E. J. Lovegrove, M. Inst. C.E., Hornsey. 1900.

LIQUID NIGHT SOIL (DISPOSAL OF).

38. *Information from various towns. Compiled by G. T. Lynam, A.M. Inst. C.E., Burton-on-Trent. 1899.

PAVEMENTS (COMPARISON OF LIFE AND COST OF GRANITE AND GRITSTONE).

10. Information from 33 towns. Compiled by C. F. Wike, M. Inst. C.E., Sheffield. 1890.

PAVEMENTS (TAR MACADAM).

46. Information from various towns. Compiled by A. E. Collins, A.M. Inst. C.E., Norwich. 1896.

47. Information from various towns. Compiled by J. Hall, M. Inst. C.E., Cheltenham. 1896.

41. Information from 19 towns. Compiled by E. A. Stickland, A.M. Inst. C.E., Windsor. 1897.

PRIVATE STREET IMPROVEMENTS (CONSTRUCTION OF WORKS OF).

13. Information from 49 towns. Compiled by W. J. Newton, A.M. Inst. C.E., Accrington. 1892.

PUBLIC BATHS AND WASHHOUSES.

42. *Information from 44 towns. Compiled by P. Edinger, Frome. 1897.

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Ref. No.

REFUSE (COLLECTION OF).

14. Information from 89 towns. Compiled by J. Price, A.M. Inst. C.E., Toxteth Park. 1891.

REFUSE (DESTRUCTORS).

15. Information from 36 towns. Compiled by W. Brooke, A.M. Inst. C.E., Richmond. 1885.

33. Information from various towns and districts. Compiled by J. Gammage, Borough Surveyor, Dudley. 1899.

REFUSE (DISPOSAL OF).

16. Information from 39 towns. Compiled by J. Price, A.M. Inst. C.E., Toxteth Park. 1896.

REFUSE (REMOVAL OF).

17. Information from 87 towns. Compiled by C. R. Fortune, Bath. 1886.

ROADS (MAINTENANCE OF MAIN IN NON-COUNTY BOROUGHS).

18. Information from 83 towns. Compiled by W. Howard-Smith, A.M. Inst. C.E., Carlisle. 1894.

ROADS (PAVING OF MAIN).

31. Information from principal towns of Great Britain. Compiled by H. Richardson, A.M. Inst. C.E., Aston Manor. 1899.

ROADS (STEAM ROLLING OF).

19. Information from 42 towns. Compiled by A. W. Parry, A.M. Inst. C.E., Reading.

ROADS (WATERING OF).

20. Information from 65 towns. Compiled by W. Dawson, A.M. Inst. C.E., Leyton. 1891.

SCAVENGING (STREET).

17. Information from 87 towns. Compiled by C. R. Fortune, Bath. 1886.

SEWAGE (DISPOSAL OF).

21. Information from 53 towns. Compiled by J. H. Cox, M. Inst. C.E., Bradford. 1892.

22. Information from 41 towns. Compiled by H. Richardson, A.M. Inst. C.E., Oldbury. 1890.

39. *Information from 172 towns. Compiled by J. W. Cockrill, M. Inst. C.E. 1900.

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Ref. No.

SEWAGE DISPOSAL WORKS.

35. *Information from various towns. Compiled by G. T. Lynam, A.M. Inst. C.E., Burton-on-Trent. 1899.

SEWAGE (PURIFICATION OF).

22. Information from 41 towns. Compiled by H. Richardson, A.M. Inst. C.E., Oldbury. 1890.

SEWERS (VENTILATION OF).

23. Information from 81 towns. Compiled by J. T. Earnshaw, A.M. Inst. C.E., Ashton-under-Lyne. 1893.

SLAUGHTER-HOUSES.

25. Information from 22 towns. Compiled by J. W. Cockrill, A.M. Inst. C.E., Great Yarmouth. 1885.

TRAMWAYS.

26. Information from 48 towns. Compiled by J. E. Swindlehurst, A.M. Inst. C.E., Burton-on-Trent. 1891.

TRAMWAYS (ELECTRIC).

34. Information from various towns. Compiled by the Town Clerk of Birmingham. 1899.

43. Information from 34 American and Canadian towns. Compiled by Chas. Mayne, A.M. Inst. C.E., Municipal Engineer, Shanghai. 1897.

UNDERGROUND TELEPHONE AND TELEGRAPH WIRES.

37. *Information from various towns. Compiled by G. T. Lynam, A.M. Inst. C.E., Burton-on-Trent. 1899.

WATER RATES.

44. Information from 25 (northern) towns. Compiled by A. W. Lawson, A.M. Inst. C.E., Borough Engineer, Rawtenstall. 1898.

WATER SUPPLY (DIAMETERS AND DEPTHS OF MAINS FROZEN IN 1895).

27. Information from 55 towns. Compiled by E. Pritchard, M. Inst. C.E., Birmingham. 1895.

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Ref. No.

WATER SUPPLY (FOR DOMESTIC AND GENERAL PURPOSES).

28. Information from 111 towns. Compiled by J. T. Eayrs, A.M. Inst. C.E., West Bromwich. 1890.

WORKMEN'S DWELLINGS.

29. *Information from 72 towns. Compiled by J. W. Cockrill, A.M. Inst. C.E., Great Yarmouth. 1897.

WORKMEN'S WAGES AND HOURS OF LABOUR.

45. Information from various Metropolitan Public Bodies. Compiled by J. R. Dixon, A.M. Inst. C.E., Vestry Surveyor, St. Leonard, Shoreditch. 1897.

30. Information from 39 towns. Compiled by R. H. Haynes, Newport, Mon. 1897.

32. Information from various boroughs. Compiled by S. E. Burgess, M. Inst. C.E., South Shields. 1899.

TRANSACTIONS OF OTHER SOCIETIES, BOOKS, ETC.

London Chamber of Commerce. Report on Secret Commissions. 1899.

London Chamber of Commerce. Report on Cement Admixtures. 1897.

British Fire Prevention Committee.

Field Work and Instruments. By A. T. Walmisley.

Glasgow Congress, 1901.

Land Surveying and Levelling. By A. T. Walmisley.

Society of Engineers.

Stresses and Strains. By F. R. Farrow.

Structural Iron and Steel. By W. N. Twelvetrees.

The Sanitary Institute.

SPECIAL REPORTS.

Bacteriological Experiments with Sewage. Borough Surveyor, Leicester. 1900.

Disposal of Refuse, etc., in Cities of Melbourne and Adelaide, Report on. City Surveyor, Sydney. 1891.

Manchester Main Drainage, Report on. City Surveyor, Manchester. 1896.

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Refuse Destructor and Electricity Works, Report on. Borough Engineer, Nelson. 1899.
Sewage Disposal, Report on. Borough Surveyor, Bradford.
Sewage Disposal Works, Specification, etc. for. Borough Engineer, Blackburn.
Sewer Ventilation, Report on. Borough Engineer, Leicester. 1899.
Steam Road Rolling, Report on. County Surveyor, Hereford. 1897.
Storage of Flood Water. Prof. H. Robinson. 1899.
Town Refuse Destructors, Report on. Borough Surveyor of Ipswich. 1896.
Tramway Traction, Report on.
—— City Surveyor, Birmingham. 1899.
—— City Surveyor, Sheffield. 1897.
Treatment and Destruction of Refuse, Report on. City Surveyor, Sydney. 1897.
Western Australian Hard Woods. Agent-General for Western Australia. 1902.

Pamphlets.

Conical Projection of Maps. R. H. Foy. 1901.
Destructors and Steam Production. W. H. Maxwell. 1901.
Formulæ and Tables of Velocities and Discharges of Sewers. T. De Courcy Meade. 1897.
Hodograph, the. T. Ferguson. 1901.
Incrustation of Iron Water Pipes. Water Engineer, Torquay.
Meteorology of Nottingham. Also Chart showing the relation of the Number of Deaths from various causes to Meteorological Conditions for 1901. Compiled by A. Brown, M. Inst. C.E., Borough Surveyor, Nottingham, and Philip Boobbyer, M.B.
Type Drawings for Melbourne Sewerage. W. Thwaites, Chief Engineer, Melbourne.

Journals.

American Electrician.
„ Electrical World and Engineer.
„ Engineering Record.
Builder.

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Contract Journal.
Electrical Engineer.
Local Government Chronicle.
Public Health Engineer.
Street Railway Journal.
Surveyor and Municipal and County Engineer (from vol. iv.).
Water.

PAPERS.

A few prints of the following Papers (contained in past Volumes of 'Proceedings') are in stock at the Offices of the Association, and may be obtained from the Secretary, *if the* Reference Number *is quoted and an addressed postal wrapper is enclosed with application.*

5. **Aldershot Municipal Works.** Nelson F. Dennis.
2. **An English Municipal Engineer's Visit to America.** G. Livingstone.
4. **Bacterial Treatment of Sewage.** G. Thudichum.
3. **Barry Railway,** Description of the Rhymney Branch of. A. Pearce.
8. **Bristol, Municipal Progress in.** T. H. Yabbicom.
28. **Bristol Tramways Electrical Installation.** J. Clifton Robinson.
40. **Building Bye-laws,** Position of Local Authorities in regard to. F. C. Cook.
6. **Bute Docks, Notes on.** C. L. Hunter.
7. **Cable Traction,** Conversion of Edinburgh Horse Tramway System into. W. N. Colam.
10. **Carlisle Electric Lighting.** C. D. Burnet.
12. **Carlisle, Public Works of.** H. C. Marks.
90. **Chichester, Municipal Engineering Works in.** James Saunders.
86. **Coal-Mining Subsidences in Relation to Sewerage Works.** F. W. Mager.
16. **Continuous Sewage Filter,** Construction of. F. Wallis Stoddart.
9. **Cork Electric Tramways.** B. Griffin.
45. **Cremation.** W. Eassie.
17. **Deal, Municipal Works in.** T. C. Golder.
11. **Drainage, London House.** L.C.C. Bye-Laws. W. Weaver.
21. **East Molesey, Public Works in.** J. Stevenson.

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29. **Electrical Works in Bristol.** H. Faraday Proctor.
13. **Electric Lighting by Municipal Authorities.** Professor H. Robinson.
15. **Electric Wiring Practice.** F. Bathurst.
41. **Fergusson's Surveying Circle and Percentage Unit of Angular Measurement.** John C. Fergusson.
46. **Filtration of River Water.** Alfred J. Jenkins.
24. **Floods Prevention Works in Bristol.** W. J. Steele.
20. **Hard Wood Paving, Wear and Weight of Traffic on.** W. N. Blair.
22. **Hard Wood Pavements in Sydney.** R. W. Richards.
23. **Hospital Tents.** C. H. Cooper.
88. **Housing of the Labouring Classes.** A. H. Campbell.
26. **Infectious Diseases Hospital at Ham Green.** Herbert W. Harding.
25. **Kent Main Roads.** F. W. Ruck.
1. **King's Lynn Municipal Works.** Henry James Weaver.
30. **Leith Docks, Notes on.** P. Whyte.
87. **Liabilities of Local Authorities under 38 & 39 Vict. Cap. 55, Sec. 24.** F. W. Mager.
27. **Light Railways.** H. T. Wakelam.
32. **Locomotives Act, 1898.** E. P. Hooley.
33. **Londonderry, Engineering Progress of.** W. J. Robinson.
19. **Macadam Road Construction, Analysis of.** C. H. W. Biggs.
36. **Main Roads under County Councils in Ireland.** R. H. Dorman.
80. **Methods of Safety for the Overhead Electric Trolley System.** Edward Manville.
37. **Metropolis Local Management Acts, Suggested Amendments of.** J. P. Barber.
18. **Motor Vehicles for Borough and County Work.** E. Manville.
83. **Municipal Sanitation.** William Weaver.
54. **Newbury Municipal Work.** S. J. L. Vincent.
39. **Norwich Municipal Works.** A. E. Collins.
92. **Nuneaton, Municipal Work in.** J. S. Pickering.
93. **Oswestry, Municipal Work in.** G. William Lacey.
44. **Power Houses, On the abuse of.** Sir W. H. Preece, K.C.B., F.R.S.
31. **Purification of Sewage by Land.** H. Royle.

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35. **Rainfall, Rate of.** J. P. Dalton.
50. **Restoration of Municipal Buildings.** H. A. Cutler.
85. **Rifle Ranges and their Public Provision.** J. W. Bradley.
51. **Ripon, Municipal Works in.** W. Edson.
53. **St. George, Bristol, New Public Park.** T. L. Lewis.
38. **Sewage Pumping Machinery.** W. Fairley.
79. **Sewage Purification at Huddersfield by Bacterial and other Methods.** K. F. Campbell.
81. **Sewage Treatment.** Lieut.-Colonel A. S. Jones, *V.C.*
47. **Sewerage and Sewage Disposal Works.** J. Kemp.
34. **Shipley Municipal Works.** I. Lindow.
91. **Southend-on-Sea, The Municipal Works of.** Alfred Fidler.
63. **Stafford Municipal Works.** W. Blackshaw.
48. **Staines Reservoirs Works.**
84. **Stoddart's Improved Sewage Filter,** Experiments with. T. H. Yabbicom.
65. **Sunderland Electric Lighting.** J. C. Snell.
89. **Swadlincote Public Works.** Thomas Kidd.
49. **Tonbridge, Municipal Work in.** W. L. Bradley.
14. **Tramways, Wear and Maintenance of.** C. F. Wike.
82. **Wear of Roads by Horse Haulage and Motor Traffic.** W. Worby Beaumont.
70. **West Cumberland, Water Supplies.** R. Pickering.
72. **Wimbledon, Electric Lighting Scheme.** A. H. Preece.
73. **Wimbledon, Municipal Work.** C. H. Cooper.
52. **Wolverhampton Cold Storage and Ice Factory.** George Green.
42. **Wolverhampton Corporation Tramways Electrical Equipment.** C. E. C. Shawfield.
43. **Wolverhampton Corporation Electric Tramways, 1902.** George Green.

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VOLUNTARY EXAMINATIONS.

SYLLABUS.

THE INCORPORATED ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS undertake the holding of Voluntary Pass Examinations for Candidates for Surveyorships under Municipal Corporations and the Local Government Acts.

Two or more Examinations are held in each year, one at least, in April, in London, and one at least, in October, in some provincial town to be fixed on by the Council and duly advertised beforehand.

The Council will accept applications to sit at these Examinations in order of priority, as far as accommodation permits, but reserve the right of returning or transferring any application to an Examination to be held, if necessary, on a subsequent date, in which case due notice will be given.

The Examinations are by written papers and *viva voce*, upon the four following subjects:—

Engineering as applied to Municipal work.
Building Construction and Materials.
Sanitary Science as applied to Towns and Buildings.
Municipal and Local Government Law as relating to the work of Municipal Engineers and Surveyors.

Candidates are not necessarily required to answer all the questions set in each paper: marks are given for all questions correctly answered. Where the subject is sub-divided, at least one question should be attempted in each sub-section.

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The Examinations occupy three days, and the arrangements are as follows:—

First day	.. 10	to	1	..	Sanitary Science.
„	.. 2	„	6	..	Building Construction.
Second day	.. 10	„	1	..	Municipal and Local Government Law.
„	.. 2	„	6	..	Engineering.
Third day	.. 10	..		..	*Vivâ voce* Examination.

Fifty per cent. of the total number of marks given are required to constitute a pass.

Each candidate must fill up a Form of Application, to be returned in accordance with date given thereon.

Candidates must have attained their twenty-second birthday.

The fee for each Examination is 4*l.* 4*s.*, two guineas to be paid on application, and the balance on the day of examination. Should the candidate fail, he is entitled to present himself at any subsequent Examination, on payment of 2*l.* 2*s.*, one guinea to be paid on application and one guinea on the day of Examination.

Candidates who sat and failed at any of the Examinations held prior to and including April 1898, pay 1*l.* 1*s.* entrance, and 10*s.* 6*d.* sitting fees.

No further charge is made to the candidate than the fees above mentioned.

Candidates who do not present themselves for examination forfeit their entrance fee.

Successful candidates receive a Certificate in the form of a "Testamur," signed by the acting Examiners, and sealed and countersigned by the President and Secretary of the Association in Council.

No information as to the result of an Examination, beyond the fact of a candidate having "Passed" or "Failed," is given.

Questions set at Examinations held prior to 1902 can only be obtained in the volumes of the 'Proceedings.' On sale by Messrs. E. & F. N. Spon, Ltd., Publishers, 125 Strand, W.C. The questions set at subsequent examinations are not published.

No exemption from any portion of the Examination is granted to candidates.

Any inquiries referring to the Examinations should be directed to Mr. Thomas Cole, Secretary to the Association, 11 Victoria Street, London, S.W., and should be accompanied by an addressed foolscap envelope.

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SUBJECTS OF EXAMINATION.

I.—ENGINEERING AS APPLIED TO MUNICIPAL WORK:

A. Surveying and Levelling.
B. Hydraulics.
C. Sewerage and Sewage Disposal.
D. Water Supply.
E. Road Making, including Tramways and Bridges.

II.—BUILDING CONSTRUCTION: STRENGTH OF MATERIALS:

A. Materials.
B. The Construction of Public and Private Buildings.
C. Building Bye-laws.
D. Public Baths and Hospitals.

III.—SANITARY SCIENCE AS APPLIED TO TOWNS AND BUILDINGS:

A. Heating and Ventilation.
B. Scavenging and Disposal of Refuse.
C. Water Supply and Drainage of Buildings.
D. Disinfection.

IV.—MUNICIPAL AND LOCAL GOVERNMENT LAW AS RELATING TO THE WORK OF MUNICIPAL ENGINEERS AND SURVEYORS.

NOTE.—The Examiners do not recommend any particular text-books, as it is desired to make the Examinations rather a test of the candidate's practical knowledge of the subjects generally, than to find his acquaintance with any particular book or books.

EXAMPLES OF QUESTIONS.

The following questions have been compiled from Examination Papers set to Candidates, and serve as examples of the questions asked under the different sections.

DIRECTIONS.—You are particularly requested to write legibly, and to answer the questions as concisely as possible. *Put your number at the top of every book handed in.* Prefix the number of the question to each answer. Where the subject is subdivided, at least one question should be attempted in each sub-section. Wherever possible, freehand sketches or diagrams should be drawn to illustrate the answer; these should be carefully executed, as they will be taken as showing the candidate's proficiency in this style of drawing. Candidates must not, during the examination, refer to any books or manuscript, nor communicate with each other.

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Subject:—ENGINEERING as Applied to Municipal Work.

A. Surveying and Levelling.

1. It is desired to range a straight line joining two fixed points, neither of which is visible from the other because of the intervention of a fold in the land: both ends can be seen from anywhere along the central half of the line: show how you would range this line.
2. (*a*) Describe contour lines and their object.
   (*b*) State how the positions of contour lines are determined.

B. Hydraulics.

1. Explain the terms "hydraulic mean depth" and "wetted perimeter," and their relation to each other.
2. What are considered self-cleansing velocities in sewers of small and large diameters respectively? When does a circular pipe discharge its greatest volume?

C. Sewage and Sewage Disposal.

1. State the nature and proportions of the materials for a concrete sewer, and the test you would apply to secure strength.
2. Describe the system of purifying sewage by means of an open septic tank and contact beds, and the principal parts of the works required for dealing with the sewage.

D. Water Supply.

1. Draw a cross section of an embankment 50 feet high to an open reservoir, showing a puddle wall; and figure the inside and outside slope.
2. Give a description of the different methods of gauging the flow of water and the formulæ used in connection therewith.
3. Give amount of water required per head per day in a town of 20,000 persons, purely residential, and divide the quantity under the usual heads.

E. Road-making, including Tramways and Bridges.

1. Sketch a cross-section of a 50-foot road, including paved side-paths, showing cross falls and method of formation, and furnish short description of materials to be used.
2. Describe briefly each system of mechanical traction in use on street tramways in this country, and state the advantages or disadvantages of each.
3. For a carriage-road wrought-iron girder bridge, say of 200 feet span and 40 feet wide over all, state the live and dead load, about, to be provided for.

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SUBJECT :—BUILDING CONSTRUCTION.

A. MATERIALS.

1. What descriptions of timber are best suited for the construction of outside work? Name them in order of merit.
2. Write a specification of good hair mortar.
3. Give the proper thicknesses of sheet lead in lbs. per square foot used on roofs in various parts, giving the trade terms.

B. THE CONSTRUCTION OF PUBLIC AND PRIVATE BUILDINGS.

1. What is meant by a "king post" and a "queen post" principal? Make a sketch of each, with scantlings, applied to spans of 25 feet and 50 feet respectively, and state distances between the principals.
2. What proportions of cement, sand and broken brick or stone would you specify for concrete for
   (*a*) Foundations for main walls.
   (*b*) Concrete stair landings.
   (*c*) Water-tight work.
3. Draw a figured section of a wrought-iron girder over a shop, 20 feet clear span, to carry front wall of house, two stories, 23 feet total height, and the floor joists of two rooms, the thickness of the wall to be 1½ brick.

C. BUILDING BYE-LAWS.

1. State the means of ventilation required to be provided for a "habitable room without a fire-place."
2. What proportion do the "Model Bye-Laws" prescribe for the open space in rear of a dwelling, and how to be measured?
3. State generally the requirements of these bye-laws as to—
   (*a*) The levels, widths and construction of new streets.
   (*b*) The construction of water-closets in a building.

D. PUBLIC BATHS AND HOSPITALS.

1. Give sketches and descriptions of a covered swimming-bath pond, and of the heating and overflow arrangements thereof.
2. In case of a temporary hospital for immediate requirements, give sketch plan showing position of closets, bath, nurses' room and administrative departments.

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Subject:—SANITARY SCIENCE as Applied to Towns and Buildings.

A. Heating and Ventilation.

1. How would you warm and ventilate a ward in an infectious diseases hospital?
2. Describe various methods of ventilating sewers, and give opinions as to the merits or otherwise of the same.
3. Describe the system you would employ for ventilating a theatre of average size, assuming your own conditions.

B. Scavenging and Disposal of Refuse.

1. Describe, so far as house refuse is concerned, the best mode of collection.
2. How many cells would you specify in a refuse destructor for a population of 40,000 in a residential town?
3. Give a short description of the "conservancy" systems of disposal of town's refuse, and the advantages or disadvantages of each system.

C. Water Supply and Drainage of Buildings.

1. State the advantages of soft water and of hard, comparatively.
2. A dwelling house is to be erected on damp subsoil; describe in detail the necessary works to render it dry and healthy.
3. What gradient would be necessary in 4, 6 and 9-inch pipe to ensure self-cleansing?

D. Disinfection.

1. Describe a disinfecting station suitable for a town of 40,000 population, noticing the special points, and giving the principal dimensions. Give an approximate estimate of cost excluding land, stating cost of 9-inch brickwork per square yard.
2. Describe various forms of disinfecting apparatus.
3. What method would you adopt to prevent the spread of infectious disease which has broken out in a crowded portion of the district?

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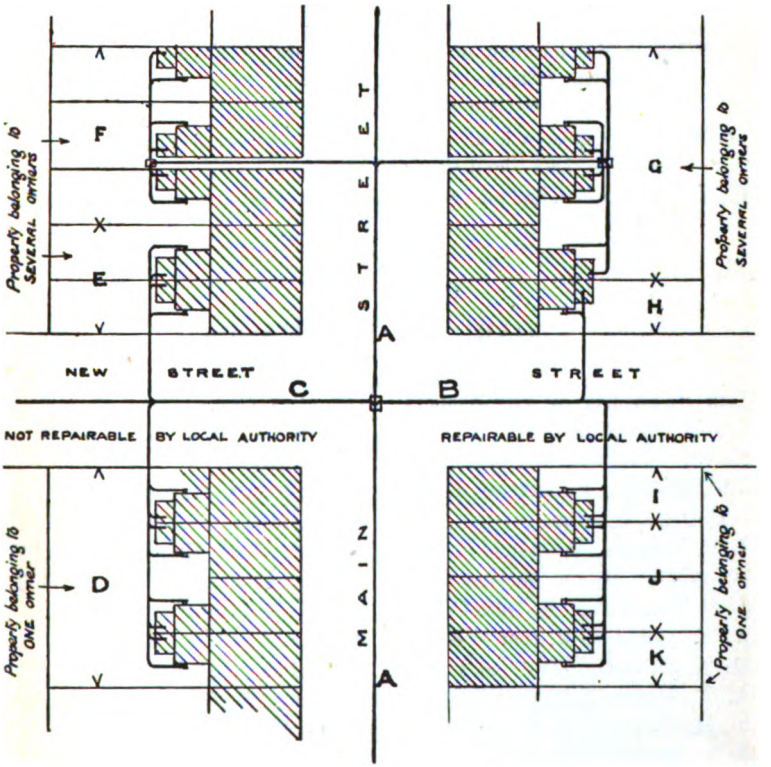
SUBJECT:—MUNICIPAL AND LOCAL GOVERNMENT LAW AS RELATING TO THE WORK OF MUNICIPAL ENGINEERS AND SURVEYORS.

1. Mark on the accompanying plan which are "sewers" and which are "drains" in connection with the streets A, B and C, and the properties D to K respectively, giving the grounds upon which you base your conclusions.



2. State the provisions of the Public Health Acts Amendment Act, 1890, with respect to "Sanitary Conveniences for manufactories." What number of water-closets should you consider sufficient for (*a*) 100 males; (*b*) 100 females?

3. Specify the duty of a local authority with respect to (*a*) nuisances; (*b*) epidemics.

4. Give a short outline of Act for Housing of the Working Classes, and the responsibility of a local authority where the same has been adopted.

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5. Describe the differences in the execution of the work and in making out the apportionment of cost in the event of the Private Streets Act, 1892, having been adopted by the authority.
6. An urban authority desires to widen and improve a public street. State the different methods of proceeding. Name the various Acts, and clauses.
7. What are the regulations prescribed in the Tramways Act, 1870, with regard to opening, breaking up and altering the level of roads by a tramway company for the purpose of making, maintaining and renewing a duly authorised tramway?
8. What is the meaning of the term "main road," used in the Local Government (England and Wales) Act, 1888, and in the Highways and Locomotives (Amendment) Act, 1878?
9. What steps must a local authority take before commencing sewerage or sewage works without their district?
10. In what manner, and under what Act, may ruinous or dangerous buildings be dealt with?

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35th Examination, October 1901.

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W. J. Goodwin.
N. M. Ingram.
W. Moss.
J. E. Parr.
W. I. Tait.
W. Thompson.
F. W. Turton.
C. D. White.
J. H. Williams.

36th Examination, April 1902.

F. Dawkins.
W. C. Glass.
E. H. Howatson.
W. H. Masters.
E. J. Miles.
R. Phillips.
W. T. Redford.
T. M. Richards.
S. Taylor.
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F. Wilkinson.
W. W. Williams.

37th Examination, April 1902.

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E. Y. Harrison.
W. J. Haskins.
F. Hewitt.
C. E. Hines.
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J. Maden.
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A. S. West.
J. Wibberley.

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Memoirs of Deceased Members.

The Council having been requested to append some short notice of the decease of Members of this Association, will feel obliged by early notice being forwarded to the Secretary, with such particulars as it may be desirable to insert in these 'Proceedings.'

JOHN COOPER was born in Culross on the north shore of the Firth of Forth, on the 27th October, 1843, and after receiving his scholastic education at the Burgh School, and at Dollar Academy, he served an apprenticeship as a joiner in Dollar. Like a large number of the youth of country towns, he sought fortune elsewhere, and, after remaining for a considerable time in Glasgow, obtained employment with one of the largest building firms in Edinburgh. In 1872, an assistant being required in the Burgh Engineer's office, Mr. Cooper applied and was selected to fill the appointment. During the next few years he attended engineering and other classes at the Heriot-Watt College, to qualify himself for the duties of a municipal engineer. In 1880 he became principal assistant to the late Mr. Fraser, then Burgh Engineer, and on the death of that gentleman in the following year, Mr. Cooper was appointed Burgh Engineer, which office he held with much acceptance to the town council and public generally until his death.

Shortly after Mr. Cooper's appointment as Burgh Engineer, there commenced a period of great municipal activity in Edinburgh, as evidenced by large drainage schemes, street improvements, house sanitation, and schemes for the housing of the working classes. Among the largest of the drainage works carried out under Mr. Cooper's directions were the covering in of Broughton Burn, the construction of Powburn outlet sewer from Edinburgh to the sea, West Murchiston drainage, Queen's Park outlet sewer, the Water of Leith sewerage, and Morningside drainage. He took an active part in the acquisition of the properties necessary for street widening, and in the slum

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schemes and improvement areas dealt with by the Corporation, not only in obtaining the condemnation of the old properties, but in the rehousing schemes which necessarily followed. When the conversion of the horse tramways into cable traction was finally decided, Mr. Cooper was appointed Joint Engineer with Mr. W. N. Colam to carry out the work, and had he lived a little longer he would have witnessed the completion of the undertaking.

Mr. Cooper was a man of great energy and very considerable mental ability, both of which he devoted solely to the public service, and his great ambition was to work up his staff to the highest point of efficiency. Towards the end of 1900 he contracted a cold, and was laid aside for about a fortnight, but, feeling better, he returned to his duties, which he continued to perform until the 21st February following, when he was obliged to give in, and after an illness of nearly six months he died on the 9th July, 1901. (Excerpt Min. Proc. Inst. C.E., vol. clxvii. 1902.)

Mr. Cooper was elected a Member on the 18th December, 1886. He served the Association as a Member of Council, and also as a Vice-President.

Mr. T. T. MARKS, late Town Surveyor of Llandudno, died on the 19th September, 1901. He was one of the earliest Members of the Association, having been elected on the 2nd May, 1873.

Mr. G. H. LILLEY, late Surveyor to the Urban District Council of Ashby-de-la-Zouch, died on the 10th May, 1901. He was elected a Member on the 11th March, 1892.

Mr. W. L. WALKER, late Surveyor to the Rural District Council of Wrexham, died in April 1902. He was elected a Member on the 27th June, 1901.

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